A

TREATISE

ON

SOILS AND MANURES,

AS

FOUNDED ON ACTUAL EXPERIENCE,

AND

AS COMBINED WITH THE LEADING PRINCIPLES

OF

AGRICULTURE:

IN WHICH THE

THEORY AND DOCTRINES OF SIR HUMPHRY DAVY,

AND OTHER AGRICULTURAL CHEMISTS,

ARE RENDERED FAMILIAR TO THE EXPERIENCED FARMER.

BY A PRACTICAL AGRICULTURIST.

PHILADELPHIA:
PUBLISHED BY B. WARNER, 171, HIGH STREET.

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PREFACE.

THEORY would always coincide with *practice*, if the speculator could hold to the mind's eye a complete model of the subject discussed; could see all the parts in action together, as a machine is surveyed; and measure excitements and obstructions precisely as they operate. But, in treating of arts which depend for their success on natural operations, the most difficult part of the task is, to assign the proper degree of influence to the many causes and qualities which act invisibly, and cannot be controlled by man. Hence, the philosopher who exercises the strongest intellect on previous *systems* of *Agriculture*, and on the knowledge accumulating from the progress of *practical experience* and *scientific discovery*, cannot be certain that some latent intermediate impulse in the machine of vegetation, has not eluded his anxious inquiry, or that he is aware of all the causes which exist, and of their conducing to a general effect.

Amidst these difficulties, the *Theorist* cannot advance any considerable way beyond the track of *experience*, in the pursuit of materials for a new system, without being liable to move on a line which *subsequent experience* may be compelled to abandon. Meanwhile, an independent and equally specious hypothesis may uphold the reasonableness of some branch of established practice impeached by the new system, and vindicate from

the name of prejudice that slow and circumspect transition from tried courses to alleged improvements, which prevents a whole country from being involved in the speculations and risks of an experimental farm.

The views of Sir Humphry Davy in regard to *Soils* and *Manures* may, on many fundamental points, be received without dispute, as no less sound and practical than they are original and ingenious: but he has advanced some new doctrines, and become the advocate of some recent partial practices, which do not accord with the general experience of Gardeners and Agriculturists. Nevertheless, by the connection with the subtile principles and problems of Chemistry under which these are given, the Practical Farmer who may feel dissatisfied with a particular part of the professor's theory, because it is at variance with his own maxims derived from experience, is perplexed and silenced by the reasoning, being unable to enter with perspicuity into the grounds of argument drawn from the depths of philosophy: thus he is ashamed to question a train of deductions by which he is conducted to a doctrine in which he does not confide. But when theory is opposed to theory, the practical man is disembarrassed, and raised to the situation of an arbiter.

It may be added, that some few points among the difficulties of Chemistry, treated by Sir Humphry Davy as fundamental principles, are not yet considered as established by all the great Chemists; consequently, the speculative deductions from these must stand over for approval, until the assumed principle be exploded or confirmed.

In the following Treatise, the leading doctrines of this illustrious Contributor to the formation of an enlightened system of Agriculture are brought under review; in order that such as are obviously well founded, or tenable against superficial objections, may be recommended to *general practice;* as well by corroborating facts and observations, as by the connected order and simplified form in which they are presented;—and that such as are open to considerable objection, either on practical grounds, or by collision with a contrary hypothesis, may be exhibited at the tribunal of *reason,* and subjected to the test of *experience,* in so plain a shape as shall bring them within the grasp of the Practical Agriculturist who may have formed no previous acquaintance with Chemical Science.

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TREATISE

ON

SOILS AND MANURES.

USE OF THE SOIL.

CORRECT views of the office of the soil disclose the rationale of approved modes of tillage; if one mode is found superior to another, they lay open the cause of it; and proceeding from courses which are experienced to be beneficial, a principle is thus obtained for extending their application.

One great use of the soil, is to afford a bed for the plant, and a cover for its roots from the sun and from the wind; while the roots, by taking hold of the ground, act as stays and supports for the trunk of the plant. A second important office is that both of a depository and a channel of nutriment: In these relations, the soil ought to contain a certain proportion of common vegetable basis, and of peculiar substances found in plants on analysis; it ought again to be easily permeable to air; also porous, for the percolation of water and passage of fluid manures; well fitted for allowing a plant, by the fine tubes within its roots, to derive sustenance slowly and gradually from the dissolved and soluble substances mixed with the earths.

As the systems of roots, branches, and leaves, are very different in different vegetables, so specific plants have a preference for peculiar soils in which they flourish most. The plants that have bulbous roots require a looser and lighter soil than such as have fibrous roots: and those of the latter, which have short and slender fibrous radicles, demand a firmer soil than such as have tap roots or extensive lateral roots. Hence, when successive crops of the same plant have drawn out from a soil the peculiar properties most adapted to its individual nature, the bed of earth becomes less fit for the same plant, until it has been rested and recruited: while it may be fitter for some other plant of a different constitution than it originally was; though exhausted in regard to the crop which it has long borne, it may be fresh for a new sort of vegetable. In short, the principles laid down in the "Practical Gardener," (Introduction to the KITCHEN GARDEN, under the head *Rotation of Crops*,) are more or less applicable to all the branches of Gardening and Agriculture.

BASIS OF SOILS.

Sir Humphrey Davy, an illustrious ornamant of the English school of Chemistry, is not more distinguished by his discoveries in philosophy, than by seeking, with true ambition, to make profound knowledge subservient to the common arts by which the common wants of mankind are supplied; he has contributed largely to the service of agriculture, by publishing his scientific researches into the composition of earths, and the true food of plants. With the object of founding a course of agricultural improvement on fixed principles, he has communicated, in the *Elements of Agricultural Chemistry*,* some very important results from a systematic train of experiments. We propose to lay before the Reader the substance of his leading conclusions, divested, as much as possible, of chemical terms; and to review the peculiarities of his system with candour and independence; concentrating, for unity of method, scattered articles belonging to the same branch of rural economy.

In the extensive field of his inquiry, he touches on the principles of many other arts; it therefore becomes necessary, in sketching an outline after him, which shall embrace only the department of agriculture, to connect the extracts by details and observations for which Sir H. Davy is not responsible.

"Soils, in all cases, consist of, either a mixture of finely divided earthy matter,†—or of earthy matters not reduced to powder, such as gravel and other stones; more or less combined with decomposed animal or vegetable substances; saline ingredients, also, frequently lodge in a soil; and the earthy matters are frequently accompanied with the oxides of minerals, particularly the oxide of iron.‡ The earthy matters form the true basis of the soil; the other parts, whether naturally present, or artificially introduced, operate in the same manner as manures.

Four Earths generally abound in soils:§ 1. The *aluminous*, *i. e.* Clay, including alum; 2. The *siliceous*, *i. e.* Flint, in various stages of decomposition, including flinty sand; 3. The *calcareous*, *i. e.* Limestone, under various modifications, including marle, chalk, and chalky sand; 4. The *magnesian*, *i. e.* Magnesia, a stone sometimes mistaken for common limestone, but when burnt and applied to land it is much longer in passing from a caustic to a mild state, and under most circumstances is highly pernicious to vegetation. The small proportion in

* This work, which will be frequently referred to, is entitled, *Elements of Agricultural Chemistry, in a Course of Lectures for the Board of Agriculture.* By Sir Humphry Davy, LL.D. F.R.S. &c. &c. 8vo. American, 1820.

† Ibid. p. 15.

‡ Ibid. pp. 111, 123.

§ Ibid. p. 15.

which it may be sometimes beneficial, will be afterwards explained.

The above are the only earths which have been hitherto found in plants.

Other primitive earths sometimes enter into soils by the pulverization of rocky materials.

TERMS FOR SOILS DEFINED.

The popular terms for soils are seldom applied with precision. What one man calls a marle, another will call a clay; and so on. But if a general circulation and acceptance could be obtained for the principles of definition judiciously laid down by Professor Davy—according to which a soil is to be styled a clay, sand, or chalk; a marle, loam or peat; or a compound of these—the characteristic terms would be every where intelligible.

In framing a system of definitions, a soil is to take a particular denominationfrom a particular kind of earth, not exactly in proportion as that earth may preponderate, or not, over others in forming the basis of the soil, but rather in proportion to the influence which a particular kind of earth, forming part of the staple, has on tillage and vegetation. Thus, as clay is a substance of which a comparative small quantity will give a cold and stubborn character to a soil, the name *clayey* is often properly bestowed, where the quantity of pure clay to be collected from a given piece of land, is but as 8 to 42, compared with the quantity of sand which another field may contain, and yet barely deserve the denomination of *sandy*.

"The term CLAYEY should not be given to a soil which contains less than one-sixth of aluminous matter;" because less than that will not be attended with the common effects which govern the culture, and limit the crops, for a clayey soil.

The epithet SANDY is not an appropriate distinction for any soil that does not contain at least seven-eight parts of sand; and sandy soils are to be distinguished into *siliceous sandy* or flinty sand, and *calcareous sandy* or chalky sand.

The word CALCAREOUS, or any denomination implying the presence of mild lime or chalk, is not properly applied unless a specimen of the soil is found strongly to effervesce with acids, or unless water having a channel in the soil affords a white earthy deposit when boiled.

A MARLE consists of mild lime with a small proportion of clay, and sometimes of peat, with a mixture of marine sand and animal remains; the lime having originated, for the most part, from the decomposition of sea-shells.

A soil may be treated as MAGNESIAN, where but a small

comparative quantity of magnesian stone is present; as will be explained in treating of Magnesia as a manure.

The combination of animal or vegetable matter in an *inferior* proportion with earthy matter, but not lower than one-sixth, makes a LOAM: the word *loam* should be limited to soils containing at least one-third of impalpable earthy matter (distinguishable by the touch from sand, chalk, or clay,) combined with decayed animal or vegetable substances not exceeding half the weight of the mere earth; the earthy matters may comprehend aluminous, siliceous, or calcareous ingredients, and in some cases be mixed with mineral oxides: according to the proportions of which, the soil may be red loam, brown loam, or black loam; and in regard to the basis, a clayey loam, a sandy, or a chalky loam.

A *superior* proportion of vegetable matter, that is to say, an excess of this above half the bulk of the earthy basis, makes a PEAT. To bring this kind of soil into successful cultivation, the quantity of vegetable matter must, in most cases, either be reduced or counterbalanced by the admixture of some of the simple earths.

Where a slight tincture of any particular mineral substance has a strong effect on vegetation, this quality should be indicated by a corresponding word prefixed to the principal name for the soil. Thus the presence of either *salts* of iron, or *sulphate* of iron, ought to be marked by prefixing the term FERRUGINOUS to the denomination taken from the basis, to remind the cultivator that the effect on vegetation will be pernicious, unless he has recourse to an effective remedy. If on the contrary, *oxide* of iron be found in the soil, there is seldom any occasion to notice it in the name: in small quantities, it forms a useful part of soils, and has been found to constitute from a 15th to a 10th part of several highly fertile fields: it is found in the ashes of plants. To persons unacquainted with chemistry it may be useful to add, that *salt of iron* exhibits the crystals obtained from iron by the action of an acid fluid. *Sulphate of iron* is Copperas, a native kind of which is produced in some soils by the effect of the springs and earths on each other. Black *oxide of iron* is the substance that flies off from red-hot iron when it is hammered. Iron appears to be only hurtful to vegetation in its acid combinations. See *Tests of Soils*.

IMPROVEMENT OF SOILS.

Almost all the expedients for improving, enriching, or correcting a soil, known to agriculturists, may be comprehended under one of the following heads:

1. The admixture of Earths to improve the Texture of the Soil.
2. Draining.
3. Paring and burning.
4. Turning in Green Crops as Manure.
5. Fallowing.
6. Irrigation.
7. Applying Earths as Manures.
8. Introducing Mineral or Saline Elements as Manures.
9. Manuring with Refuse Substances not excrementitious.
10. Manuring with Excrementitious Substances.

I. *By the Admixture of Earths, to improve the Texture of the Soil.*

This is a distinct thing from applying Earths as a manure. It is of avail in proportion as the smallness of the tract, or the value of the plant, to be cultivated, allows the free introduction of new earths, until the staple of the land is composed as desired. Almost all sterile soils are capable of being thus improved; and sometimes the latent pernicious quality which destroys the value of an extensive tract of land, can be corrected without much expense.

The best constitution of a soil, is that in which the earthy materials are properly balanced, so as to combine as many advantages of different ingredients as are compatable, and so as to obviate the defects attending any single kind of earth.

The ground, or basis of the soil, should be well adapted for the admission of air, and for the percolation of moisture, without retaining it in winter.

A well-tempered aptness in the soil to absorb water from air, and to retain it in a latent form, is clearly connected with fertility. The power to absorb water by attraction, and to hold moisture without being wet, depends on the mechanical structure of the particles of earth, and the balancing effect of different earth. Thus sand will attract moisture, but will not keep it long under the influence of heat. Clay will long retain water which has fallen upon it, and always keep moist under a humid atmosphere: but in continued dry weather, with summer heats, the surface of it, being baked into an almost impenetrable crust, is little capable of absorbing moisture. Hence crude clays form equally bad lands in extremely wet or extremely dry seasons. Chalk is of a middle nature, in this respect. It results, that the soils best adapted for supplying the plant with moisture by atmospheric exhaustion are compositions* of sand

* Elements of Agricultural Chemistry, p. 141.

finely divided clay, and pulverized chalk, with a proportion of animal or vegetable matter.*

There is besides, in particular earths, an agency subservient to vegetation, which depends on chemical affinities, in those earths, for elementary substances floating in the air, or deposited in the soil. Thus, both pure clay and carbonate of lime have an attraction for volatile oils and solutions of oil and saponaceous matters, and for much of the pulpy stuff first disengaged from organic remains. Hence a limited proportion of these earths contributes to form a *rich* and *generous* soil; because they long preserve in their pores the prepared nourishment of vegetables, parting with it gradually as it is drawn by growing plants, and refusing it to the fainter action of air or water.

The properties of a soil may be aggravated or tempered by the nature of the SUBSOIL. When the upper layer rests upon a bed of stone, or of flinty gravel, it is much sooner rendered dry by evaporation; an effect which is beneficial, or otherwise, as the climate is moist in excess, or inclined to aridity. A clayey foundation counteracts the readiness of flinty sand to part with moisture to a drier climate; so does a bed of chalk in a less degree.

A soil is neither fit for tillage nor pasture, if it consist entirely of impalpable matters,† or of pure clay, pure silica, or pure chalk. Sand may abound in a higher proportion than the more tenaceous earths, without causing absolute barrenness. Thus a tolerable crop of turnips has been raised on a soil of which eleven parts in twelve were sand. A good turnip soil from Holkham was found to contain $\frac{8}{9}$ parts of siliceous sand. If the quantity of impalpable earth and finely divided organic matter be a little increased beyond what a sand plant requires, it will suffice for good returns of barley. Although wheat depends more on a rich staple, happily the constituents of land fit for it are combined with very great diversity. An excellent wheat soil, from Middlesex, afforded $\frac{3}{5}$ of sand; the rest was chalk, silica, and clay, pretty equally distributed, with a proportion of organic matter so surprisingly small (only 22 parts in 500) that it may be apprehended some considerable substance, convertible into food for a growing plant, might be included in the chalk. Chalk may in the next degree form the preponderating earth of good soil. A large portion of England is chalk;

* The compound of earth, which seems every where most favourable to vegetation, is that which consists of one-third of chalk, half of sand, and a fifth of clay: from a Paper *on the Chemical Analysis of Soils*, translated from the Italian of Fabbroni, by Arthur Young, Esq. (*Annals of Agriculture*, vol. viii. 173.)—"A fifth of clay:" this proportion is too large; independent of consumable or cropping manure; by which the clay should be reduced to one-sixth or lower.

† Elements of Agricultural Chemistry, p. 133.

and many of the districts where it is the staple earth, liberally repay cultivation.*

The Warp-land (alluvial soil) in the East Riding of Yorkshire, is a strong clayey loam, the fertility of which can hardly be equalled. The sediment gradually adding to the depth of this warp-land, being brought from the higher country by the numerous rivers and streams which open into this common estuary, is composed of a variety of substances. Decomposed vegetable and animal matter should be from *one-eighth* to a *fourth* of the bulk of the earthy substances, according to the dependence of the expected crop on the nutritive power of the soil.

Many soils (observes Sir H. Davy) are in popular language distinguished as *cold;* and the distinction, though at first view it may appear to be founded on prejudice, is as just on philosophical principles as it is consonant to the experience of the farmer. Some soils are constituted for imbibing a much greater degree of heat from the rays of the sun; and of soils, brought to the same degree of heat, some cool much faster than others. Soils that consist chiefly of a STIFF WHITE CLAY, take heat slowly; and being usually very moist, they retain their heat only for a short time. CHALKS are similar in being slowly heated: but being drier, they retain heat longer. A BLACK SOIL CONTAINING MUCH SOFT VEGETABLE MATTER, if the site and aspect dispose it to dryness, is most heated by the sun and air: all the COLOURED SOILS, especially those containing much carbonaceous matter (charcoal,) or ferruginous matter (iron,) are disposed for acquiring a much higher temperature than PALE-COLOURED soils. When soils are perfectly dry, those that most readily become heated by the solar rays, likewise cool most rapidly. Moisture without fermentation retards the accession of heat, and accelerates its escape. The faculty of absorbing and retaining moisture has been already brought under notice. The method of detecting the presence of some ingredient in the soil which the eye cannot perceive, and which escapes the touch when a portion of mould is rubbed between the fingers, is by having a specimen of the earth of such cubical dimensions as may be thought proper, dug out; and finding the materials of it by various chemical tests.

TESTS OF SOILS.

For the common purposes of agriculture, the natural consti-

* Mr. Strickland states the remarkable fact, that the great vein of chalk terminates in the East Riding of Yorkshire; and beyond it northward, no chalk is found in the island. See also a Map *Delineating the Strata of England and Wales, with part of Scotland,* by W. Smith, 1815.

tution of a virgin soil, or the state of improvement which land under tillage has acquired from artificial causes, can, in the great majority of cases, be sufficiently determined by taking up portions of earth in different parts of a field, regarding the soil as a separate layer from the subsoil, or strata undisturbed by cultivation; and examining these by the common lights which persons employed in agriculture have derived from experience. But when the nature of a virgin soil is entirely unknown, no previous trials of its powers having been made; or when a cultivated field unaccountably baffles the ordinary course of skilful husbandry, while lands constituted apparently like it make good returns under similar treatment; it is proper to have recourse to the aid which modern chemistry offers to agriculture, for a full and accurate knowledge of the grounds on which success may be expected, or the causes of failure explained and rectified.

The instruments required for the analysis of soils are few, and of small cost:—a pair of scales, large enough to weigh a quarter of a pound of common earth, and so delicately exact as to turn when loaded with a grain; a set of weights, corresponding with the same limits; a wire sieve, just coarse enough to pass mustard-seed; a common kettle, or small boiler; an Argand lamp and stand; two or three Wedgwood crucibles; evaporating basins; a pestle and mortar; a bone knife; some filters, made of half a sheet of blotting-paper, folded so as to contain a pint of liquid, and greased at the edges.

The principal tests, or chemical re-agents for separating the constituents of the soil, are: Muriatic acid (spirits of salts;) sulphuric acid (oil of vitriol;) pure volatile alkali, dissolved in water; solution of prussiate of potassa; solution of potassa (soap ley;) solution of neutral carbonate of potassa; succinate of ammonia; nitrate of ammonia; solution of carbonate of ammonia; solution of muriate of ammonia. Dry carbonate of potassa is sometimes wanted in fusing earths.

The quantity of soil conveniently adapted for a perfect analysis is from 200 to 400 grains. It should be collected in dry weather, and exposed to the atmosphere till it becomes dry to the touch.

Independently of regular analysis, the specific gravity of a soil assists to indicate the quantity of animal and vegetable matter it contains; because the atoms of either are lighter than the atoms of clay, of sand, or of lime. In proportion as a soil is light, it may be presumed to be rich. Before a soil is analysed, the other physical properties of it should also be examined; because they denote, in a sensible degree, the sorts of earth in its composition, and serve to guide the order in which the chemical tests are applied. *Siliceous* soils are generally rough to the touch, and scratch glass, when rubbed upon it; *calcareous* soils (besides effervescing with acids, a trial to be afterwards descri-

bed,) when in the shape of sand, do not scratch glass; and *clay*, while it is generally distinguishable by the touch, neither scratches glass nor effervesces with acids; *ferruginous* soils are, for the most part, of a red or yellow colour, or rusty-brown.

1. Measure of Absorbent Power by the Dissipation of Latent Water.—After soils have been dried by continued exposure to the air, they still contain a considerable proportion of water which adheres to the earths, and to the animal and vegetable rudiments, in such obstinate combination, that it can only be driven off by a high degree of heat. To free a specimen of soil from as much of this water as may be, without otherwise affecting its constitution, let it be heated for ten or twelve minutes over an Argand's lamp, till its temperature attain 300° of Fahrenheit. If a thermometer be not used,* the proper maximum of heat may be measured by keeping a piece of wood in contact with the bottom of the dish: While the colour of the wood remains unaltered, the heat is not excessive: as soon as the wood begins to be charred, discontinue the process. If a higher heat were applied, the vegetable or animal matter would be decomposed, and all the following train of experiment be rendered illusory.

The loss of weight in the soil thus dried should be noted, as indicating the absorbent power of the soil. Supposing the specimen to have previously weighed 400 grains, the loss of fifty (or an eigth part) denotes a soil absorbent and retentive of water in the greatest degree: such a soil will generally be found to contain either much vegetable or animal matter, or a large proportion of aluminous earth, in which two respects this indication is equivocal; but the tests to follow will decide. When the loss is only from a twentieth to a fortieth part of the whole, the soil is but slightly absorbent, and siliceous earth probably forms the greatest part of it.

2. Separation of Gross Fragments.—Loose stones, gravel, and vegetable fibres, are carefully kept in the specimen until after the water is dissipated; for they participate, in different degrees, in that power of absorbing moisture which affects the fertility of land. After the process of heating, detach these; by bruising the soil gently in a mortar, and passing it through the sieve. Take separate minutes of the weights of the vegetable fragments, and of the gravel and stones; distinguishing the nature of the latter. If calcareous, they will effervesce with acids; if siliceous, they will scratch glass; and if aluminous, they will be easily cut with a knife, and will refuse the tests of lime and flint.

3. Separation of the Sand.—The greater number of soils contain varying proportions of sand more or less granulated. It

* Elements of Agricultural Chemistry, p. 112.

is necessary to separate the sand from the impalpable or more finely divided matters; such as clay, loam, marle, vegetable and animal atoms. To do this, boil the sifted mass in four times its weight of water: when the texture of the soil is broken, and the water cooled, alternately shake the sediment in the vessel, and suffer it to settle; for in subsiding, the different parts will be distributed in layers. Thus treated, the coarse sand will generally separate in a minute, and the finer in two or three minutes, while the infinitely small earthy, animal, or vegetable matters, will continue in state of mechanical suspension: so that by pouring the water from the vessel after three minutes, the sand will be found divided from the other substances. The other substances, with the water containing them, must be deposited in a filter, to be analysed as under 4. Meanwhile the sand is to be examined, and its quantity registered. It is either calcareous or siliceous; and its nature may mostly be detected as that of stones and gravel, without a minute analysis. If it consist wholly of carbonate of lime, it will rapidly dissolve in muriatic acid, with effervescence; but if it consist partly of this, and partly of siliceous sand, the latter will be found unchanged after the acid dissolving the lime has ceased to effervesce. This residuum must be washed, dried, and heated strongly in a crucible. Its weight is then ascertained by the balance; and that, deducted from the weight of the whole, indicates the quantity of calcareous sand dissolved.

4. Analysis of the Finely-divided Matters.—The water passing through the filtre is to be preserved; for if any saline particles or soluble animal and vegetable elements existed in the soil, it will be found to contain them. Meanwhile the fine solid matter left on the filter must be collected, and dried. This is usually a compound exceedingly multifarious; it sometimes contains all the four primitive earths, as well as animal and vegetable matter. To ascertain the proportions of these with tolerable accuracy, is the most difficult part of the assay.

i. Test of Lime in a Solid State.—Of muriatic acid take twice the weight of the promiscuous soil; and dilute the acid with double the measure of water. Let the mixture remain for an hour and a half, stirring it frequently.

By this time, if any carbonate of lime or of magnesia existed in the soil, they will have been dissolved in the acid; which sometimes takes up likewise a little oxide of iron, but very seldom any alumina.

The fluid should be passed through the filter. Then let the solid matter be collected, washed with rain water, dried under a moderate heat, and weighed. The loss denotes the quantity of solid matter taken up.

ii. Test of Iron.—Add the washings to the solution, which, if not sour to the taste, must be made so by the addition of fresh

acid. The test now to be added to the whole, is some triple solution of prussiate of potassa and iron. If a blue precipitate occurs, it indicates the presence of oxide of iron; and more of the triple solution must be dropped in till this effect ceases. In order to weigh the precipitate, it must be collected and heated red. The result is oxide of iron, with perhaps a little oxide of manganesum.

III. TEST OF LIME SUSPENDED IN A FLUID:—ALSO OF MAGNESIA.—Having taken out all the mineral oxide, next pour into the fluid a solution of neutralized carbonate of potassa, continuing to do so until it will effervesce no longer, and till both the taste and smell of the mixture indicate an excess of alkaline salt.

The precipitate that falls down is carbonate of lime: it must be collected on the filter, and dried at a heat below that of redness.

The remaining fluid must be boiled for a quarter of an hour; when the magnesia, if any exist, will be thrown down, combined with carbonic acid. To bring it into a state for being weighed, treat it as the carbonate of lime.*

IV. TEST OF ALUMINA INCIDENTALLY DISSOLVED AND PRECIPITATED.—If any minute proportion of alumina should have been dissolved by the acid employed in the first test, it will be found with the carbonate of lime in the precipitate obtained by the third. To separate it from the carbonate of lime, boil it for a few minutes with as much soap lye, or solution of caustic soda, as will cover the solid matter. Soap lye thus applied dissolves alumina without acting upon carbonate of lime.

V. MEASURE OF THE MATTER DESTRUCTIBLE BY RED-HEAT.—After the finely-divided promiscuous soil has been acted upon by muriatic acid, the next step is to ascertain the quantity of insoluble animal and vegetable matter which the residuum contains.

Set it in a crucible over a common fire; and let it be ignited till no blackness remains in the mass; stirring it often with a metallic rod so as to expose new surfaces successively to the air. The loss of weight ultimately caused, shews the quantity of substance destructible by fire and air.

When the smell emitted during the incineration resembles that of burnt feathers, it is a certain indication either of animal

* In case the soil be sufficiently calcareous to effervesce very strongly with acids, Professor Davy gives us a method of measuring the quantity of carbonate of lime, by collecting the carbonic gas expelled by the acid in a pneumatic apparatus described verbally in the *Lectures*, p. 116. This gas is to be either measured or weighed; and it will bear the proportion of 43 to 100 to the original weight of the carbonate of lime. This may be a very simple process to an expert chemist; but it is neither so easy to describe, nor so cheap to practice in occasional experiments, as that above. In an outline like this, for popular use, it is therefore sufficient to notice it.

matter or of some substance analogous to it: on the other hand, a copious blue flame uniformly denotes a corresponding proportion of vegetable rudiment. It will accelerate the destruction of matter decomposable by ignition, to throw gradually upon the heated mass some nitrate of ammonia, in the proportion of one-fifth to the weight of the residual soil.

VI. SEPARATION OF THE PARTS INDESTRUCTIBLE BY HEAT.—The remaining parts are generally minute atoms of earthy matter, comprehending alumina and silica, combined with oxide of iron, or of manganesum.

To separate these, boil them in little more than their weight of sulphuric acid, diluted with four times its weight of water.

The substance keeping a solid form after this treatment, may be considered as siliceous. Let it be collected on the filter, washed, dried, and weighed.

If the residuum contained any oxide of iron, or of manganesum, they will have been dissolved by the sulphuric acid. To throw down the oxide of iron, add in excess succinate of ammonia. When this has been done, introduce soap lye, to dissolve the alumina, and to precipitate the oxide of manganesum. Heat the oxides to redness, and then weigh them.

Should any magnesia and lime have escaped solution by the first test, that of muriatic acid, (which is rarely the case,) they will be found in the sulphuric acid. Their quantities are ascertained by a similar process to that above.

(COURSE SOMETIMES SUBSTITUTED FOR "V. and VI."—If very great accuracy be the object, dry carbonate of potassa must be employed as the agent; of which four times the weight of the subject must be put with it into the crucible, and heated red for half an hour. The mass indestructible by heat must then be dissolved in muriatic acid, and the solution evaporated till it is nearly solid. In this state, add to it distilled water, by which the oxide of iron, and all the earths, except silica, will be dissolved in combination as muriates. The silica, after filtration, must be heated red. The other substances are separated as from the muriatic and sulphuric solutions above. Where the soil to be analysed contains stones of doubtful composition, this process is well fitted to determine their character.)

VII. EVAPORATION OF THE DIGESTING WATER.—The water first used for boiling the earth as under I. 3. (and which was directed to be kept for a separate trial) will contain whatever saline matter, or soluble vegetable and animal rudiments, existed in the soil.

This water must be evaporated to dryness at a heat below boiling.

If the solid matter obtained be brown in colour and inflammable, it may be regarded as vegetable extract, unless in com-

bustion it emit a smell like that of burnt feathers, which indicates animal or albuminous matter. If any portion be white, crystalline, and not destructible by heat, it may be considered as saline in its properties. The saline matter altogether bears a minute proportion to the other constituents; and as most of it is generally common salt, the following tests need seldom be resorted to. Salts of potassa are thrown down by a solution of platina. Sulphuric acid combined with any salt is detected in a solution of baryta by a dense white precipitate. Salts of lime assume a cloudy appearance in a solution containing oxalic acid. Salts of magnesia cause a similar cloudiness in a solution of ammonia. Muriatic acid is discovered by forming clouds in a solution of nitrate of silver. Salts containing nitric acid sparkle when thrown on burning coals.

VIII. PROCESS FOR DETECTING SULPHATE OF LIME, AND PHOSPHATE OF LIME.—Sulphate of Lime (Gypsum) is to be detected by another independent process; on which is engrafted a method of getting at Phosphate of Lime in a separate state. First, put the residuum, with one-third of its weight of powdered charcoal, into a crucible: and heat the mixture red for half an hour. The mass is afterwards to be boiled in water, (half a pint to 400 grains,) for a quarter of an hour. Filter the whole: expose the collected fluid for some days to the atmosphere; and so much gypsum as the soil comprised will be gradually deposited as a white precipitate.

Then to separate the Phosphate of Lime from the solid residuum, digest upon it muriatic acid more than sufficient to saturate the soluble earths. Evaporate the solution, and pour water upon the remains. The result will dissolve the earthy compounds, and leave the phosphate of lime untouched.

When Sulphate of Lime and Phosphate of Lime have been thus disengaged in a solid form, it is sometimes necessary to deduct a sum equal to their weight from the amount of the Carbonate of Lime; but that is only when the latter has been calculated by the loss sustained in solid matter, part of which enters into the new compounds from which the Sulphate and Phosphate have been recovered.

IX. FORMULA FOR RECAPITULATING THE RESULTS.—When the analysis of a soil is finished, add the quantities together; and if they nearly equal the original portion of soil,* the assay may be confided in as accurate.

Four hundred grains of a good siliceous sandy soil from a hop garden near Tunbridge, Kent, gave these results:—

	Grains
Water of absorption - - - - - - - - -	19
Loose stones and gravel, chiefly flinty - - - - - - -	53
Carried over, - - - - - - -	72

* Elements of Agricultural Chemistry, p. 120.

	Brought forward,	72
Undecomposed vegetable fibres		14
Fine siliceous sand		212
Minutely divided matter separated by successive tests.	Carbonate of lime	19
	Carbonate of magnesia	3
	Matter destructible by heat, chiefly vegetable	15
	Silica	21
	Alumina	13
	Oxide of iron	5
	Soluble matter, principally common salt and vegetable extract	3
	Gypsum	2
	Loss	21
		400

x. Popular Application of detached Steps in the Process.—The assay may be very much simplified, when the inquiry is confined to one leading object. Thus, if it be merely wished to know, whether a soil contain already so much lime as to make it inexpedient to bring on lime as a manure, it will be enough to put the specimen into a dish, and to pour upon it a quantity of muriatic acid: indeed when no other experiment is to be grounded on this trial, good white-wine vinegar may be employed. If the soil immersed in acid effervesces strongly, it is sufficiently charged, or perhaps overcharged, with lime. In a similar way, one or two essential questions may be sometimes solved by resorting to any of the other tests, either alone, or two or three connectedly, in a different order from that which has been set down.

CORRECTIVES OF ILL-CONSTITUTED SOILS.

The following are simple and efficacious correctives of some bad ingredients in soils, or the excess of some good constituent; the presence of which frequently disappoints even the skilful cultivator, when either the true cause is not suspected, or an appropriate remedy is not known.

1. A farmer with a great portion of common skill is often baffled by Iron in its acid combinations. If on washing the specimen of a sterile soil, it is found to contain the Salts of iron, Sulphate of iron, or any Acid matter, it may be ameliorated by a top-dressing of quick lime; which converts the sulphate of iron (copperas) into a manure.

2. If there be an Excess of pure calcareous matter (chalk or lime) in a soil, its constitution may be improved by turning in, in a green state, some of those vegetables which possess the greatest quantity of acid; also by the application of sand or of clay, with a small proportion of oxide of iron (blacksmith's sweepings) not exceeding $\frac{1}{20}$ part. The same object may be obtained by irrigating with any calybeate water (water containing

iron,) or by the addition of peat containing vitriolic (i. e. sulphuric) salts; both which are calculated to turn lime or chalk into gypsum.* See under VII. 5. why gypsum is sometimes beneficial and sometimes not.

3. When an EXCESS OF CARBONATE OF LIME (charcoal united to lime) requires the quality of the soil to be modified, gypsum applied as a manure, also oxide of iron applied as a corrective, seems to produce the very best effects. Carbonate of lime is mild lime in combination with charcoal absorbed from decayed vegetable or animal matter. The diversified effects of lime as a manure are explained under VII. 1.

4. Soils REDUNDANT IN SAND are benefited by a top dressing of peat or other vegetable matter, or of decayed animal matter, or by a mixture of clay. Also, if the sand be not calcareous, by marle.

5. An EXCESS OF VEGETABLE MATTER is to be removed either by burning, (See III. *Paring and Burning*,) or by the application of earthy materials. The fundamental step in the improvement of peat land, or a bog or marsh, is draining. SOFT BLACK PEATS, after being drained, are often made productive by the mere application of sand or clay, as a top dressing: sand is greatly to be preferred. When PEATS are ACID, or contain FERRUGINOUS SALTS, calcareous matter is absolutely necessary in bringing them into cultivation. When they ABOUND IN THE ROOTS AND BRANCHES OF TREES, the wood must either be grubbed up and carried off, or destroyed by burning; so when the face of peat is incumbered by living plants CONTAINING MUCH WOODY FIBRE, and therefore not proper to be ploughed in the ground, the field must be cleared by one of the same methods.†

6. Where there is a REDUNDANCY OF CLAY in a soil, (and if the quantity of clay exceed one-sixth of the general mass, it is desirable to reduce the proportion,) one of the best dressings which can be applied is a mixture of sand and mild lime; the rubbish of mortar containing both these materials, is an excellent thing to improve the texture of a clayey soil. Clay appears to receive no improvement from lime alone. Sea-sand may be used alone with good effect. It would be also highly beneficial to introduce as much fermented dung or decayed vegetable matter as would entitle the land to the denomination of a loam.

II. *By Draining.* No perennial crops, and but few annual plants, can be successfully cultivated where the land is exposed to winter floods, or where the subsoil is rendered wet by undersprings, or by heavy leakage from neighbouring pieces of water lying higher and imperfectly banked off. The importance of

* Elements of Agricultural Chemistry, p. 141, 226.
† Ibid. p. 142.

draining peat land has been adverted to under I. 5. Where open drains would be unsightly or inconvenient, as in the interior of a domestic garden, or ornamented ground, a paved brick drain is in the end cheaper than a rubble drain, because the latter is liable to be soon choked by the roots of trees.

III. *By Paring and Burning.* It is obvious, that in all cases the process of BURNING must destroy a certain quantity of vegetable matter; and it must principally be useful where an excess of this matter renders the soil too rank. It must be of eminent service in reducing to charcoal, or wood ashes, a great accumulation of woody fibre already overrunning the field; for woody fibre is very slowly reduced to the state of vegetable mould, if left to the process of a natural dissolution: nor is it very rapidly reduced by lime or other solvents artificially applied.

Burning likewise renders clays less coherent; and in this way greatly improves their texture, and causes them to be more permeable to water,* and consequently, less retentive of it in stagnant masses. Another cause of the unproductiveness of cold clayey adhesive soils, is, that the seed is coated with matter impenetrable to air.† When clayey or tenacious soils are burnt, their power or tendency to absorb water from the atmosphere is diminished in the proportion of 7 to 2; and they are brought nearer to a state analagous to that of sands; the particles are less adhesive, and the mass less retentive of moisture. Thus the process of burning, properly applied may convert a matter that was stiff, damp, and in consequence cold, into one powdery, dry, and warm; altogether more fitly constituted as a bed for vegetable life. The great objection made by speculative Chemists to paring and burning is, that the animal and vegetable matter in the soil is diminished:—But where the texture of the earthy ingredients is permanently improved, there is more than a compensation. To meet the objection still more directly, where an excess of inert vegetable matter is present, the destruction of a part of it must be beneficial; and the carbonaceous matter in the ashes may be more useful to the crop, than the unreduced vegetable fibre, of which it is the remains,‡ could have been.

The most speedy way of bringing under tillage a meadow overrun with rushes is; first to drain it, and then to pare off a thick turf and burn it.

The cases in which burning must incontestably be prejudicial, are those of sandy dry flinty soils containing little animal or vegetable matter: here it can only be destructive; for

* Elements of Agricultural Chemistry, p. 22.
† Ibid. p. 149.
‡ Ibid. p. 234.

it decomposes that constituent which is already below the minimum proportion, and on the presence of which, in a limited degree, the productiveness of a soil depends.*

"Burning without fire." A new method has lately been discovered of substituting quick lime for fire; and experiments made upon it before the Workington Agricultural Society gave general satisfaction. The lime in its most caustic state, fresh from the kiln, is laid upon the vegetable surface to be consumed; and before it is weakened by exposure to the air, water, just in sufficient quantity to put it powerfully into action, is applied. This fierce compound will not only consume the vegetable covering, but affects the clay, or other upper stratum, as if it had been in contact with fire. It supersedes the trouble which has hitherto attended burning; and in respect to poor soils which would be improved by the two distinct operations of burning and liming in the common mode, it bids fair to bring them sooner on a par with those of superior quality.

IV. *By Turning-in Green Crops as Manure.*—This is directly opposed to Burning Turf, in regard to intention and effect; and is particularly serviceable where the basis of vegetable mould is to be augmented, being an extension of the principle on which Paring Turf without Burning is resorted to.—When Green Crops are turned into the clod, besides enriching the staple with nutritive matter, they promote the fermentation and decomposition of woody fibre buried near the surface; and which is a useless incumbrance in an undecayed state.

"When GREEN CROPS are to be employed for enriching a soil, they should be ploughed in, if possible, when in flower, or at the time when the flower is opening; for in this stage, they contain the largest quantity of soluble matter. Green Crops, pond-weeds, the paring of hedges or ditches, or any kind of fresh vegetable matter not woody, require no preparation† to be fitted for manure. When OLD PASTURES are broken up for tillage, not only is the soil enriched by the death and slow decay of the plants which have previously deposited soluble matters in the clod; but the leaves and roots of the grasses (vegetating just before the change of culture) afford saccharine, mucilaginous, and extractive matters, which become *immediately* the food of the crop; also the *gradual decomposition of the grasses affords a supply of vegetable mould for several years.*"

After giving the substance of Sir H. Davy's theory on any specific subject in agriculture, it will not be often necessary to incur the hazard of questioning some incidental deduction from the system; because the principal branches of his theory are so consonant with experience, that they incontestibly contribute sound and intelligible principles for applying more extensively,

* Elements of Agricultural Chemistry, p. 22.
† Ibid, 191.

and with more certain effect, entire classes of means at the command of the cultivator,—where the resources to which the practical farmer had arrived, by the empirical course of laying different ingredients on land without knowing their precise operation, were previously few and limited, or their utility doubtful.

But in regard to the effect of VEGETABLE MATTERS as manures, there is a vein of doctrine pervading the theory of this great chemist, which seems to be taken up independently of experience, and without calculating all the principal relations belonging to the subject:—which doctrine is, that to bury vegetable manure without fermenting, and leave it gradually to decompose in the soil, will prolong its fertilizing power for several seasons. So it will:—but what will be the intermediate state of the soil? Surely the capacity of the land for growing healthy plants cannot be equal to that of a clean soil where the manure is not applied till it is ready to afford nutriment.

This part of the theory is in opposition to the practice of rotting turf before it is turned into the soil, or of waiting till it has become rotted before a new crop is introduced. There will be several occasions of adverting to this principle again, and of viewing every side of it as it may catch different lights in different positions, particularly under Sect. V. *By Fallowing*, and the head MANAGEMENT OF MANURE FROM THE HOMESTEAD.

V. *By Fallowing*.—Sir Humphry Davy seems to under-rate the utility of fallowing, and to be disposed to recommend the non-fallowing system.

The following is the substance of the observations occurring in different parts of his Work on this subject. (1st.) "The chemical theory of fallowing is very simple. Fallowing affords no new source of riches to the soil. It merely tends to produce *an accumulation of decomposing matter, which in the common course of crops would be employed as it is formed;* and it is scarcely possible to imagine a single instance in which a cultivated soil can lie fallow for an entire year with advantage to the farmer. The only cases where this practice is beneficial seems to be in the destruction of weeds, and for cleansing foul soils.*

"The benefits arising from fallows have been much overrated. A summer fallow, or a clean fallow, may be sometimes necessary in lands overgrown with weeds, particularly if they are sands,—which cannot be pared and burnt with advantage: but it is certainly unprofitable as part of a general system of husbandry."†

(2dly.) "It has been supposed by some writers, that certain

* Elements of Agricultural Chemisty, p. 22.
† Ibid, 239.

principles necessary to fertility are derived from the atmosphere, which are exhausted by a succession of crops, and that these are again supplied during the repose of the land, and the exposure of the pulverized soil to the influence of the air: but this, in truth, is not the case. The earths commonly found in soils cannot be combined with more oxygen; none of them will unite to azote; and such of them as are capable of attracting carbonic acid, are always saturated with it on those soils on which the practice of fallowing is adopted. The vague ancient opinion of the use of nitre, and of nitrous salts in vegetation, seems to have been one of the principal speculative reasons for the defence of summer fallows. Nitrous salts are produced during the exposure of soils containing animal and vegetable remains, and in GREATEST ABUNDANCE IN HOT WEATHER: but it is PROBABLY by the combination of azote, escaping from those remains, with oxygen in the atmosphere that the acid is formed; and at the expense of an element which would otherwise have been converted into ammonia; the compounds of which, as is evident from what is stated under VIII. 2, are much more efficacious than the nitrous compounds in assisting vegetation."*

(3dly.) "When weeds are buried in the soil, by their gradual decomposition they furnish a certain quantity of soluble matter: but it may be DOUBTED, *whether there is as much useful manure in the land at the end of a clean fallow, as at the time the vegetables clothing the surface were first ploughed in. Carbonic acid gas is formed during the whole time by the action of the vegetable matter upon the oxygen of the air; and the greater part of it is lost to the soil in which it was formed, and dissipated in the atmosphere.*

"The action of the sun upon the surface of the soil tends to disengage the gaseous and the volatile fluid matters contained in it; and heat increases the rapidity of fermentation: and in the *summer fallow*, nutriment is rapidly produced at a time when no vegetables are present capable of absorbing it."†

(4thly.) "Land when it is not employed in preparing food for animals, should be applied to the preparation of manure for plants; and this is effected by means of GREEN CROPS, in consequence of the absorption of carbonaceous matter from the carbonic acid of the atmosphere. In a *summer's fallow*, a period is always lost in which vegetables may be raised, either as food for animals, or as nourishment for the next crop; and the texture of the soil is not so much improved by its exposure as in winter, when the expansive powers of ice, the gradual dissolution of snows, and the alternations from wet to dry, tend to pulverize it, and to mix its different parts together."‡

* Elements of Agricultural Chemistry, p. 240.
† Ibid. ‡ Ibid.

The Reader has now before him the arguments directed by Sir H. Davy against the practice of fallowing, as part of a general system of husbandry.

But cannot some of the above objections to the giving of a periodical rest to land after an exhausting crop be obviated? and are not the benefits of a summer fallow, when admitted to be necessary, in some respects undervalued?

In the first place, this eminent philosopher observes, that fallowing "MERELY tends to produce an accumulation of decomposing matter, which in the common course of crops would be employed as it is formed." But this accumulation of decomposing matter is alone a great acquisition; it is in many cases the precise restorative wanted to keep up the proportion of vegetable mould necessary to fertility. Supposing the milder course of crops to employ the decomposing matter as it is formed,—how are plants which depend still more on the nutriment lodged in the soil, to be grown in full crops, where the quantity of manure is limited by local circumstances, unless the elements of vegetation are allowed to accumulate for a season, at periods adjudged proper by a manager acquainted with the power of the soil and the course of crops?

Secondly, in opposition to the idea that certain principles necessary to fertility are derived from the atmosphere, Sir Humphry enters on a speculative train of reasoning,—against which it would be presumptuous to appeal, had he offered a positive conclusion as a great chemical authority: but some of the assumed data—such as that the "earths commonly found in soils cannot be combined with more oxygen"—seem to skirmish with the conclusion ["Nitrous salts"... to the end of the paragraph;]—nor has the "*vague ancient opinion* of the use of nitre and of nitrous salts in vegetation" been subverted or discountenanced by the experiments of modern physiologists, many of whom have found that plants will grow in nitre alone, which is more than the ancient opinion requires in its support. And as to the final inference,—"but it is PROBABLY by the combination," &c. the uncertainty disclosed in the word "probably," deprives the argument of all decisive effect in a practical point of view for although the Professor is acquainted with the operation of gases as far perhaps as experiment will ever trace it, the manner in which nitrous salts are produced in soils containing animal and vegetable remains, is but guessed at by him, and not explained to us with the authority of certain knowledge.

Thirdly, this distinguished Chemist, after virtually admitting, that the weeds which were overrunning the land must enrich it by being buried in its bosom, further observes:—"But it may be DOUBTED, whether there is as much useful manure in the land at the end of a clean fallow, as at the time the vegetables clothing the surface were first ploughed in."... &c. &c.

To this speculative objection the answer must necessarily take a speculative turn.

If there be less manure in the land at the close of a fallow, the quantity lost must have escaped in the shape of vapour, and been dispersed in the atmosphere. It may be worth while to inquire how far this is to be estimated as a loss?

In opposition to the theory of Sir Humphry Davy on this point, it is quite consistent with good logic to suppose, that whatever escapes from the dissolving mass of a dead plant in the form of vapour, and does not fall down to the earth by condensation, is easily and most naturally taken up by a new growing plant from the atmosphere, through the leaves; that is to say, whatever has a tendency to fly off into the air is to be recovered by communication with the air.

On this subject the theory of the author of these remarks is as follows:—

To form the bulk of a growing plant,—certain SUBSTANCES comprehended under some of the descriptions of matter common to vegetables, and which appear on analysis to be combined differently in different species, are taken up by the roots from the soil, and by the leaves from the air, through the medium of congenial fluids: in succulent plants a greater proportion of food is received by the leaves than by the roots, so that even the bulk of the plant, or the basis of the sap, is in such kinds increased chiefly by derivations from the air.

To imbue a common insipid basis with those distinguishing peculiarities which make different species growing in the same soil differ in scent, flavour, and the qualities which are salutary or pernicious in food and medicine,—certain SPECIFIC ESSENCES, or volatile aëriform atoms, invisible either from being colourless or minutely divided, are taken up entirely by the leaves from the air; the character of the plant having been originally fixed by a portion of the peculiar essence being lodged in the seed so as to attract to it only volatile particles of its own nature.*

Hence in mixed masses of manure, the manure may be considered better adapted for general purposes, when the volatile properties peculiar to specific plants and to animal bodies have escaped, and when the residuum is nothing more than the matter common to vegetable and animal bodies.

It may seem to be a loss, that the gaseous essence, escaping into the atmosphere, is dispersed over an immeasurable region of air, and carried by winds over the face of the earth, instead of being retained for the enrichment of a particular field. To

* This theory will go a considerable way towards affording a solution why the blossoms and fruit of a graft should preserve their distinguishing peculiarities, unaltered by connexion with the stock.

this it may be answered, that the gases of which the air is constituted—oxygen, azote, and carbonic acid gas—though differing in their specific gravity ar rather levity, are found to be combined in any cubical quantity of air in a proportion which never materially varies ;* and it is quite reasonable to suppose, that the volatile salts or spirits, or aromatic principles, which constitute the essences of plants, are distributed equally over the atmosphere by the same law. The quantity of volatile essence floating within reach of the attraction of an individual plant must, indeed, be allowed to be evanescent even to the confines of nothingness, when the transparency of the air is considered, and the multiplicity of different essences of which infinitely small divisions are supposed to be floating in it. But if, on the other hand, we advert to the elastic nature of the air, and the property which it is found to have of always preserving its natural equilibrium, the most scanty provisions of volatile food in the vicinity of a plant is abundance. Thus, suppose a plant to take up carbonic acid gas with great avidity ; although the proportion of carbonic acid gas is extremely small, yet the plant cannot drink up the quantity in immediate contact so fast, but the same quantity will be constantly preserved in the air surrounding it ; for gas of the same nature is incessantly pressing into the temporary void where the interchange of natural air is unrestricted. The supply of a peculiar essence to plants, by the medium of the common air, may be rendered sufficiently ample by obedience to the same law.

It may therefore be one of the benefits of a fallow, to lose every thing which can escape by a free exposure of the putrefying remains which promiscuously accumulate in a soil.

On the hypothesis which has just been sketched, the objection of Sir H. Davy, that " the action of the sun upon the surface of the soil tends to disengage the gaseous and the volatile fluid matter that it contains, and heat increases the rapidity of fermentation,"—may be enlisted among the arguments in favour of a summer fallow. In cases where a restorative course is desirable, the objector also becomes an ally who urges, that " in the summer fallow nutriment is rapidily produced at a time when no vegetables are present capable of absorbing it."

Fourthly, with regard to the superior utility of ploughing in Green Crops, as recommended in the Elements of Agricultural Chemistry, instead of a fallow :—There can be no difference of opinion where the land is poor, or exhausted, without being foul; that is to say, when it wants recruiting with manure, but not cleaning of root-weeds to the full depth of the soil. Plants which quickly decompose, such as the lettuce, are most conducive to

* In a given volume of air, their proportions are usually found to be : Oxygen $\frac{21}{100}$; azote $\frac{79}{100}$; carbonic acid gas $\frac{1}{500}$ *max.* $\frac{1}{800}$ *min.*

the object of exciting a fermentation in fibrous woody remains as well as enriching the land. This subject has been already touched under Sect. IV.

To return to the question of fallowing. It is merely to disembarrass the practical manager, that so much has been said by way of theory against an hypothesis on *non-fallowing*, which is made to depend on assumptions from chemical principles too little capable of proof from experiment to be safely adopted in this branch of agriculture.

Some of the incidental statements, in the above abstract from the Professor's Lectures, are decidedly adverse to practical maxims in which most farmers, and the majority of writers on husbandry, including the Reports from Agricultural Societies, concur;—the statements, for example, that 'sands are benefited by a summer fallow more than clays;' and that the 'land is not richer at the end of such a fallow than it was before.' On the contrary, the conclusion to which the registered courses of profitable husbandry lead, is very much like the following summary.

1. Land is uniformly recruited during a fallow: this is proved by the circumstance, that, in all soils, *a much less quantity of dung is necessary after a summer fallow;* and on some lands none is wanted; nay, the experienced Cally is of opinion, that dunging naked fallows is in many cases better dispensed with, and has often, in tolerable loams, made the crop to fail.

2. Clays are unfit for green crops, the substitute for a summer fallow; and hence are necessitated to adopt the latter, in rotation with white crops.* A winter fallow merely is, indeed, an excellent thing in light grounds, and as a preparation for spring wheat; but it will not do with clays, which require a thorough drying and pulverizing, before they can profit by the falling juices, which would only render the earth more hard and compact. A summer fallow is, therefore, more proper for this soil.†

3. Light soils only can dispense with fallows. The question therefore is narrowed to this compass: Whether the benefit of a summer fallow, on a sandy or other light soil fit for green crops, is equal to the loss of a year's rent, or to the difference between the profit of a green crop and the rent for one year paid on a naked fallow? The general conclusion is,—that it is not; and that a summer fallow for light soils is too costly.

By a rotation of crops, every ingredient in the manure applied is successively turned to profit; for those parts of it which are not fitted for one crop remain as nourishment for another.

* *Letter by the President of the Workington Agricultural Society*, dated Nov. 20, 1814.

† *Philosophical Magazine for Jan.* 1815. *No.* 1. *p.* 12.

Different soils require a different rotation, and the practice of one district afford no absolute rule for another. Local circumstances will always influence the course of crops; yet a survey of some of the rotations, which after long trial are found to be repeatedly beneficial on the principal sorts of land, tends to enlarge the resources of farming; and if brought from a distant part of the island, the chance of a beneficial exchange of information, in some respects new, is increased. The following communications are gathered from a voluminous work, entitled *General Report of the Agriculture of Scotland*, published under the superintendance of Sir John Sinclair.

Benefit of Green Crops.—"The introduction of *Turnips* and *Clover* has been the means of rendering productive those inferior soils which it was impossible to cultivate under the old system of successive corn crops. Even on land of a better quality, the crops which succeed these are so much more abundant, that it is probable as many bushels of corn now grow on the half of a given extent of ground as were formerly raised on the whole. In this view alone, almost the whole value of the turnips and clover may be said to be a clear gain. *Faliow* has been banished from all dry soils by turnips; and where land is laid down to pasture, one acre of clover and rye-grass will fatten more cattle than could barely exist on ten acres left full of weeds to be casually sown, after several years, with natural grasses.

"When turnips were first introduced on farms, and for some time after, the most common application of them was to the fattening of cattle. Sheep did not then form any important part of the stock of arable land: but on light soils the full benefit of this crop was not obtained, until it had become the practice to consume the greater part of the crop on the ground by sheep. The poorest sandy soils seldom fail to yield an abundant crop of corn after turnips thus consumed on the ground. They are thus at once manured and strengthened in the staple.

"On dry loams, the best practice is a medium between the old and the new; and the crop is divided between the sheep and the fold-yard, by drawing off and leaving a few ridglets alternately.

"The vast addition made both to the quantity and the quality of the dunghill, by the consumption of green clover and turnips, powerfully recommends them; and turnips accordingly are cultivated for this very purpose, on soils but little adapted to their growth as an edible root. When grown on clayey soils, the whole crop is still carried to the fold-yard, for the object of converting the haulm into manure.

"So the best mode of consuming clover and rye-grass is to pasture it, especially on thin dry soils; compared with which

the mode of reserving the entire crop for hay is very unprofitable.

" On lands less fit for pasturing, deep loams and clays, *soiling* is resorted to. A considerable portion of the grass is cut green for horses and milch cows; and in some instances, both for rearing and fattening of cattle. This economical use of the grass in the homestead augments and enriches the dunghill."

ROTATION WITHOUT A SUMMER FALLOW.

" The most common rotation on the best dry soils is one of four years. 1. Wheat or oats (assuming the previous crop to have been an artificial grass.)—2. Turnips.—3. Wheat, barley, or oats.—4. Clover and rye-grass; one moiety of the farm being under green crops, and the other under white crops. But on siliceous sandy soils (flinty sand being the abounding ingredient) it is necessary to retain the clover and rye-grass division for some years in pasture, *unless more manure is applied to such land than can be returned from its own produce.*"

ROTATIONS WITH A FALLOW.

" On clayey loams the rotations are more varied. On strong clays, beans is the best relieving succession crop; and although it cannot be proposed as a perpetual substitute for a summer fallow, in alteration with wheat or any other exhausting culmiferous crop,—yet when drilled, and hand and horse-hoed, beans supersede the necessity of fallowing oftener than once in a rotation of six or eight years. Wheat and beans have been taken alternately for a series of years, even as many as eight, on the best soils; but the most frequent courses are of *four* and *six* years. The four years' course is renewed in this order: 1. Fallow; 2. Wheat; 3. Clover; 4. Oats. The six years' course revolves, with nice adaption to every crop, thus: 1. Fallow; 2. Wheat; 3. Clover and Rye-grass; 4. Oats; 5. Beans; 6. Wheat. Or the six years' rotation is sometimes varied thus: 1. Fallow; 2. Wheat; 3. Beans; 4. Barley or Oats; 5. Clover and Rye-grass; 6. Oats: but by this arrangement the land is neither so clean, nor so well pulverized, as it should be in preparation for clovers. On clayey soils a *complete fallow* is considered as the basis of every profitable rotation crop by the most judicious farmers of Scotland; and according to their concurring experience, on wet cohesive soils, however good the course of tillage, no trials, made upon a large scale, to postpone a fallow for more than eight years, have hitherto been successful in that part of the island."

Some of the *Papers* in the above-mentioned *General Report*, which record this result, allude to the climate as being wet

and humid for a greater portion of the year than in most parts of England; and in some degree attribute the failure, with them, of the *non-fallowing* system to that cause. But having no system to manufacture for universal and perpetual application, without regard to the quality of the land, or the local resources for manure,—comprehensive views, a candid independence of theory, and an exact balance of the adventure, and returns under both methods, may have a greater share than the climate in their decision.

Indeed it would be easy to multiply quotations from intelligent writers on this side the Tweed, the tenor of which agrees with the above, both in the inclination to dispense with fallowing, as far as it can be done with profit, and in the admission that on certain lands a periodical fallow conduces to eventual gain.

Very striking circumstances are connected with the *Letters on Agriculture*, from which we are going to borrow almost the counterpart of the above. First, these Letters are not behind the intelligence of the present day, though written five-and-twenty years ago; for rejecting some of the speculative notions which were then in fashion, the writer took at once the tenable ground to which experimental agriculturists have in general reverted. Secondly, they are attributed to the pen of His Majesty George the Third;—a king who, though placed by afflictions beyond the reach of flattery, is still praised and revered by his people.*

Extracts relating to ROTATIONS WITHOUT FALLOW.

"The dispute which has lately arisen on the subject of summer fallows has made me secretly wish that Mr. Ducket, the able cultivator, of Petersham in Surrey, would have communicated his thoughts not only on that subject, but would have benefited the public by a full explanation of that course of husbandry which has rendered his farm at Petersham, which has been now above nineteen years in his hands, so flourishing, though his three predecessors had failed in it."

"His course of husbandry seems to be the employing clover, turnips, and rye, as fallow crops, and as intermediate ones between wheat, barley, oats, and rye; changing them according to the nature and quality of the land."—*Letter dated 1st Jan.* 1787.

"He would in general reject the practice of FALLOWING on light soils; as feeding-crops are better,—from the cattle, while

* Mr. Young had the honour of giving them to the public in his *Annals of Agricultue*. 7th vol., to whom they were sent with all the exterior marks of an ordinary correspondent: they were subscribed "RALPH ROBINSON," and dated from Windsor.

consuming the crop, treading the soil, and rendering it more compact and firm, which a light soil requires. . . . Besides, this enables the farmer to keep a larger stock of cattle, which increases his quantity of manure."

"Thus his land, although never dormant, is continually replenished with a variety of manures, and thus unites the system of continued pasture with cultivation."—*Letter dated 5th March*, 1787.

Extract relating to WINTER FALLOWS.

It is to be premised that the texture of some lands gives them a middle nature between light and heavy; or else from local causes there is no dependence that they can be kept sufficiently dry in winter for a feeding-crop. "Many soils may be improved by winter fallows. This may be practiced by ploughing immediately after the grain crop is off in a dry season; and by being well water-furrowed during the winter; and by proper dressings in the spring: but Mr. Ducket does not think this method equal to a feeding-crop of rye, turnips, or tares."—*Letter dated 5th March*, 1787.

Extract relating to SUMMER FALLOWS.

The joint effect of this and the preceding passage is the more remarkable, because the Editor of the *Annals of Agriculture* appended to the first *Letter* the *Note* which is exhibited below.* The note bespeaks the echo of a preconceived opinion: but his Correspondent had a mind independent of that system which would invert, instead of modifying and augmenting, the "gathered wisdom" of a hundred generations. This reply is a pointed correction of the mistake in regard to Mr. Ducket.

"He thinks fallows necessary for STRONG soils, as the clods of the earth cannot be well broken to pieces without being sometime exposed to the air."—*Letter dated 5th March*, 1785.

As in gardens the land can be kept clean by the hoe, and the renovation by manure is more under the power of the cultivator, a winter fallow is in most cases sufficient.

VI. *By Irrigation.*—Irrigation is often found to be beneficial under two different kinds of circumstances; being resorted to with different intentions:

* "I have at various times, during the last fifteen years, viewed with great attention the husbandry of the very ingenious Mr. Ducket. I took notes of what I saw for my private information, but did not publish them, as I thought I perceived a disinclination in that gentleman to have them so brought forward; and on some points, he expressly desired me not. I am glad to find by this memoir (for which the Public is much indebted to the author) that he has relaxed in this particular. I wish much that Mr. Robinson, as he has broken the ice, would proceed, and in particular give his courses of crops; and explain, in particular, his *utter rejection of fallows*."

1. To obtain an alluvial deposit left by the water. In winter, on land where no crop or seed is lodged, but where annual or other plants are to be cultivated in the following season: or in autumn, whenever the crop is off the ground; or at any time when the soil of a fallow requires to be strengthened, this substituted for a more expensive manure may be applied. Also meadows may be floated at the seasons judged proper, according to the circumstances of the land, the quality of the water, and the constitution of the grass. The practice of the Fiorin School (founded by Mr. Richardson,) as reported in the Agricultural Magazine, N. S. No. 6. is in substance thus: "Some parts of the Fiorin to be irrigated in November: others in February: the floating to be continued at intervals throughout the summer; the water to be one *week, or less*, on the meadow, and *two weeks off it:* but the grass not to be mown till October." The result is not stated. In the most favourable event, this method could only be proper for grass which naturally grows on bogs, and where it is intended to be husbanded as a winter food.

2. In summer, a light shallow irrigation may be directed over land occupied with growing plants, where a long continuance of dry weather makes it desirable to draw out such a resource. This is merely watering; and not irrigating, to obtain an alluvial manure.

The winter irrigation of meadows is, in many districts, the effect of a local flood, which the farmer cannot prevent nor materially control: but the temporary mischief is followed with a rich compensation. All plants which are not aquatic, if they are covered over the tops with water, have their growth immediately arrested; and if they thus continue inundated during the winter months, the majority die down to the root, having the herb completely dissolved, and even the roots of others perish: but the vegetable matter of the plants thus decomposed adds to the depth and fertility of the soil; and such plants as survive to shoot again in spring, derive an advantage from the decayed substance of the others, as well as from the alluvial soil deposited by the water.

Sir Humphry Davy's theory on irrigation partly corresponds with the above; but one good effect which he attributes to the flooding of meadows in winter, is quite opposed to the admission of temporary injury to plants not aquatic. His words are: "In very cold seasons it [the inundation] preserves the roots and leaves of the grass from being affected by frost. . . . . Water is of greater specific gravity at 42° of Fahrenheit than at 32°, the freezing point; and hence in a meadow irrigated in winter, the water immediately in contact with the grass is rarely below 40°, a degree of temperature not at all prejudicial to the living organs of plants. [He proceeds to relate the following experiment.] In 1804, in the month of March, I examined the

temperature of a water meadow near Hungerford, in Berkshire, by a very delicate thermometer. The temperature of the air, at seven in the morning, was 29°. The water was frozen above the grass. The temperature of the soil below the water, in which the roots of the grass were fixed,* was 43°."—This insulated observation is certainly not enough to support the principle laid down by the Professor. As the water is reduced in depth, in the course of its subsiding and evaporating, there must happen many occasions on which the grass would lie alternately in shallow water, and alternately in thin ice, partly covered and partly exposed, and ready to dissolve as soon as any heat acts upon the moisture.

It concerns the practical farmer who has meadows which he can either float, or keep dry, to decide by close personal examination, in what manner grasses not aquatic are affected by lying under water during the frosts and other vicissitudes of winter: of this the state of the grass at the subsiding of the water in spring, and the weight of the crop, is the proper criterion.†

The Professor says in another place: "When land has been covered by water in the winter, or in the beginning of spring, the moisture that has penetrated deep into the soil, and even the subsoil, becomes a source of nourishment to the roots of the plant in summer; and prevents those bad effects that often happen to lands in their natural state from a long continuance of dry weather."‡ The alluvial matters which the water may have diffused through the veins of the land is undoubtedly beneficial: but, were the water which has conveyed them to stagnate in the subsoil, it would be more pernicious to most plants than the droughts of summer.

We now come to some other communications by this distinguished Chemist; the substance of which may be given without protest or comment as principles consistent with experience —although they are placed on an original foundation, which enlarges the sphere in which irrigation may be safely applied.

"When the water used in irrigation has flowed over a calcareous bed, it is generally found impregnated with carbonate of lime; and such water tends, in that respect, to ameliorate a soil in proportion as any of the modifications of lime and charcoal were deficient: but where these are already in excess, water charged with a limy sediment should be withheld; while wa-

* Elements of Agricultural Chemistry, p. 239.

† "Should the frost set in when the water is on the land, so that some spots should be covered with ice for some days, the spot so covered with ice will be of a *darker green*, and appear more healthy in the spring than the rest of the field. But when they come to mow the hay, the crop will be *considerably less* than that on the other parts of the field that were not covered with ice." *On Watering Meadows in Brecknockshire. Report by Mr. John Clark to the Board of Agriculture*, 1794.

‡ Elements of Agricultural Chemistry, p. 238.

ter impregated with sand, clay, gypsum, or particles of iron, would be beneficial.

"Common river water generally contains a certain portion of the constituents of vegetables and animal bodies; and after rains this portion is greater than at other times: it is habitually largest when the source of the stream is in a cultivated country.*

"In general, those waters which breed the best fish are the best fitted for watering meadows; but most of the benefits of irrigation may be derived from any kind of water—provided the soil be not already overcharged with the prevailing ingredient in the deposit left by the water; and provided, on the other hand, that the matter of the soil and the matter of the deposit are not pernicious when combined. These are general principles: 1. That waters containing ferruginous impregnations (particles of iron) tend to fertilize a calcareous soil. 2. Ferruginous waters are injurious on a soil that does not effervesce with acids, which is one of the tests of the presence of lime. 3. Calcareous waters, which are known by the earthy deposit they afford when boiled, are of most use on siliceous soils, or other soils containing no considerable proportion of carbonate of lime.†

Supposing the farmer to have a complete command over contiguous water containing a suitable alluvial deposit, he may render a cultivated level, which requires rest and a cheap manure, extremely productive with comparatively little labour, by irrigating on the above principles.

VII. *By applying Earths as Manures.*—When any decomposed mass of stone or earth is laid upon or turned into the cultivated clod, with the object—either of furnishing a SOLVENT to the remains of animal or vegetable matter which encumber the soil by their slow decay, or of enriching the land with some substance which is apparently taken up by specific plants as FOOD; then the earthy matter is applied as manure. This is a distinct province from that of merely applying earths to mend the texture of the soils as under I. But sometimes the two designs will coincide. Closely connected with the theory of manures is the inquiry, What is the true food of plants?

"The chemistry of the more simple manures, the manures which act in very small quantities—such as gypsum, the alkalies (which include potash and soda,) and various saline substances—has hitherto been exceedingly obscure. It has been generally supposed, that these materials act in the vegetable economy in the same manner as stimulants in the animal economy, or perhaps in some relations as solvents; but that in either case they merely render the common food more nutritive.

* Elements of Agricultural Chemistry, p. 238.
† Ibid, 239.

It seems, however, a much more probable idea, that they are actually a PART of the TRUE FOOD of plants, and that they *supply that kind of matter to the vegetable fibre which is analagous to the bony matter in animal structures.*"* The probability that Sir H. Davy has assigned to these substances their true office in vegetation, is much heightened by the earthy matters afforded by different plants on analysis. On a similar principle, the benefit of a small proportion of shell marl, in the compost for the pine apple, is accounted for in Abercrombie's "Practical Gardener."†

The *epidermis* of the rattan is stated to contain a sufficient quantity of flint, to give light when struck by steel; and some small proportion of minutely pulverized flint exists generally in the epidermis of hollow stalked plants, where it is of great use in serving as a support, and seems to perform an office in the feeble vegetable tribes analagous to that of the fine thin shell by which many insects are defended.

As a prelude to a survey of the effects of different earths as manures, it may be serviceable to glance at those constituents in the kingdom of nature, which appear to be the chief agents in vegetation.

Before the true constitution of *Water* was known, some philosophers and speculative horticulturists had supposed, that all the products of vegetation might be generated from water; an opinion which practical experiments have shown to be fallacious. This ancient error, and the revival of it by several eminent physiologists in the 17th and 18th centuries,‡ was founded on correct observations, in regard to the following points:—1. The presence of moisture is necessary to germination. 2. Water is the vehicle of various particles of nourishment derived both from the air and from the soil; and no manure can be taken up by the roots of plants unless it is present. 3. Various vegetables, a greater number than can be easily named, have been found to grow vigorously with the roots in contact with water without earth.

In the same manner, the existence of air-plants,—the misinterpretation of various phænomena observed in experiments on

* Elements of Agricultural Chemistry, p. 19.

† HOT-HOUSE, *Pinery*, p. 601. The first edition of the "Practical Gardener," was published before the *Elements of Agricultural Chemistry* appeared.

‡ Van Helmont, Boyle, Bonnet, Duhamel, Tillet, and Lord Kames, zealously endeavoured to establish the theory of water being the only food of plants; and Braconnot quite recently, by experiments with distilled water. Margraf, Bergman, Kirwan, Hassenfratz, Saussure, San Martino, and Davy, have exposed the fallacies of this theory. Every pound of rain water contains one grain of earth, besides other impregnations. Plants raised from pure water will vegetate only a certain time, and never perfect their seeds. Bulbous roots, which are made to grow in water, if not planted in earth every other year, refuse at last to flower, and even to vegetate.

the atmosphere, and the repeated demonstrations that without the presence of air, or of oxygen gas, neither the germination of seeds can commence, nor the offices of vegetation proceed, —have led many inventors of new hypotheses on the growth and food of plants, to attribute to the agency of *Air* greater effects than is consistent with the daily evidence that many other things are equally indispensable.

So the productive power of mere *Earth* has been exaggerated. Jethro Tull, the ingenious author of the system of horse-hoeing, and after him Duhamel, having observed the excellent effects produced in tillage by a minute division of the soil, and by the pulverization of the broken clod by exposure to dew and air, were misled by carrying these principles too far. Supposing earth to be the only food of plants, they contended, that by finely dividing the soil, any number of crops might be raised in succession from the same land, so as to render periodical fallows unnecessary. Duhamel attempted to prove that vegetables of every kind could be raised without manure: but he lived long enough to alter this opinion; his subsequent trials led to the mature conclusion, that no single material constituted the food of plants. The general experience of farmers had long before convinced unprejudiced theorists of that as a fundamental principle; and also that manures were absolutely consumed in the growth of plants.

The principles of Sir Humphry Davy are nearly, but not implicitly adopted in the following recapitulation and synthesis.

Water, and air, and earth (as the chief depository of solid organic materials,) all operate in the process of vegetation. No one principle affords the pabulum of plants: it is neither water, which may form the basis of their fluids, for it exists in all the products of vegetation; nor air, of which they give out various forms on distillation, such as oxygen, and azote, and inflammable gas; nor charcoal, which is found on analysis to be a principal constituent of plants; nor the particles of flint, and of gypsum, at other times of lime, found in the stems of most vegetables. In all cases, the ashes of plants contain some of the earths of the soil in which the plant grew; but the earthy particles never exceed $\frac{1}{50}$ in weight of the vegetable burnt. The soil is the great laboratory in which the main part of the food for common plants, or that which conduces to their gross bulk, is lodged and prepared. In proportion as some kinds of vegetables are found not to exhaust a soil, they must be supposed to derive organic materials from the air, as well as from the rain or other water with which their vessels may come in contact; further, some contributions to the substantial juices of all plants may float among the constituents of air. To all kinds of leaves and fruit, the atmosphere may pos-

sibly be the medium of the SUBTILE AND VOLATILE PARTICLES WHICH CONSTITUTE FLAVOUR AND AROMATIC ESSENCE.* The colour of plants, in regard to the constant repetition of habitual tints, may depend greatly on their free communication with light: but the colour of the foliage, flowers, and fruit, is also affected by accidents in the soil and climate. The principles of vegetable matter which escape from putrefying plants, are either soluble in water or aëriform: in the one state, they form the most useful part of manure; in the other, they swim in the atmosphere; in both states, they are capable of being assimilated by the organs of contiguous vegetables: for plants take up the elements found in their composition, either by their roots from the soil, or by their leaves from the air.

The substances found in plants on analysis may be divided into—1. Those which constitute the hard matter or frame of the plant. 2. Those which are eminently, if not solely, the nutritive materials, whether in the form of dry solids, soft pulp, or juice. 3. Those which serve as condiments, and contribute to diversify the scent, flavour, colour, and medical properties.

The first class includes the simple earths, the earthy bases of compound substances, metallic oxides, and the basis of woody and vegetable fibre, great part of which is carbon. It has been already mentioned that the earthy matter never exceeds one fiftieth part in weight of the whole plant, and it is commonly much less; lime and flint are found the most frequently; magnesia more rarely; and clay most seldom of all. No other metallic oxides occur than those of iron and manganesum.—Charcoal is a principal constituent in all plants.

The second class comprehends several substances which are common to the animal as well as the vegetable kingdom, and therefore may be regarded as directly nutritive to animals; along with a great number not generally present in vegetables to any sensible degree, although abundant in particular plants: these are, farina, or the basis of starch; gluten, or paste; gum, or mucilage; gelatine, or the matter of jelly; (these three are not always distinguishable;) albumen, resembling the white of an egg; sugar; water; wax; resin; fixed oils; fungin, a principle detected in the cucumber, abundant in mushrooms; and extract an indefinable substance, changing with the plant analysed.

The third class consists of acids, alkalies, and soluble salts; —of these the most usual is sulphuric acid, combined with sulphate of potassa; likewise common salt, and phosphate of lime. The following seem to belong to this class, though sometimes

* That is, such as are proper to the plant; for a rank soil may deteriorate the flavour of edible produce by conveying through the roots some remaining juices of a foreign substance.

in intimate combination with substances under the first or second:—tannin, or the matter tanning leather; indigo, and the various colouring matters; camphor; the bitter principle; the narcotic principle, or opiate; volatile oils.

In addition to all the elementary parts actually found, some aroma, or fugitive essence, which would belong to the third class if it could be detained, may go off in a form thinner than air, too subtile to be weighed or measured.

The accumulation in a plant of the first class of things in a due and healthy proportion, may depend principally upon the soil, as a mixture of earth; of the second, upon the manure; of the third, in a slight degree upon the local climate, but eminently upon the power natural to the plant for attracting peculiar particles in the earth and air.

After these introductory remarks on the chief agents in vegetation, it will be more easy to explain the operation of the different earths, or species of decomposed stone, which are laid upon lands as manure.

1. LIME AS A SOLVENT. (QUICKLIME.)—Lime, when first burnt, has a caustic property, speedily decomposes vegetable and animal fibre, and is soluble in water. After burnt lime has been exposed to the atmosphere a determinate time, it becomes mild, by taking up carbonic acid; loses its solubility; and becomes chalk, or carbonate of lime.

When newly burnt lime is exposed to the air, it soon falls into powder; in this case it is called Slaked Lime. The same effect is at once produced by pouring water upon it, when it heats violently, and the water disappears.

Slaked lime was used by the ancient Romans for manuring the soil in which fruit-trees grew. Nevertheless caustic lime is pernicious to vegetation, as far as it comes in contact with a growing plant. Where acid vegetable mould—a radical bane in some marshes, moors, and peat-lands—requires correction, proceed as under I. 1.

When quicklime, *i. e.* lime either freshly burnt or slaked, is mixed with any moist fibrous vegetable matter, there is a strong action between the two substances; and they form a kind of compost, of which a part is usually soluble in water. Thus lime renders matter, which was comparatively inert, nutritive; and as charcoal and oxygen abound in vegetable matters, the lime is at the same time converted into carbonate of lime.* So burnt lime, in its FIRST effect, decomposes animal matter, and seems to accelerate the progress of such matter to a capacity of affording nutriment for vegetables: gradually, however, the lime is neutralized by carbonic acid, and converted into a substance analagous to chalk; but in this case it more perfectly

* Elements of Agricultural Chemistry, p. 216.

mixes with the other ingredients of the soil, and is more pervadingly diffused, more finely divided, than mere chalk artificially applied. Burnt lime is probably more beneficial to *land containing much woody fibre or animal fibrous matter*, than any calcareous substance in its natural state,* Thus is quicklime efficacious in fertilizing peats, and in reducing under tillage soils abounding in hard roots. But when animal or vegetable remains are destitute of fibrous matter, so as not to require a powerful solvent, or when their bulk is not in too large a proportion, or their tendency to putrescency excessive and noxious, the application of quicklime is an unnecessary reduction of their strength; therefore to cover or mix them with any simple earth, or stone pulverized without burning, will be better.—See "2. MILD LIME." Lime moistened with sea-water yields more alkali (soda) than when treated with common water; and is said to have been used in some cases with more benefit as manure.†

It is most important to the Agriculturist to be apprised of the difference in the operation of common limestone, which is of a pure white colour, and another kind of limestone which has a brown or pale yellow tincture: for a disclosure of the cause of this difference, the public are indebted to Mr. Tennant. It had long been noticed, that a particular species of limestone found in the north of England, when applied in its burnt and slaked state to land, in considerable quantities, either occasioned absolute sterility, or considerably injured the crops for many years. Mr. Tennant, by a chemical analysis, discovered that this kind of limestone differed from the common, by containing *magnesian* earth: and from several horticultural experiments, he ascertained that magnesia, applied in large quantities, in its caustic state, is pernicious to vegetation. Under common circumstances, the lime from the magnesian quarry is, however, used in small doses, upon fertile soils, with good effect; and it may be applied in greater quantities to soils containing a very large proportion of vegetable matter.‡ See, further, "3. MAGNESIA;" also some restraints on the use of quicklime, in the fourth paragraph of the next article.

2. MILD LIME, powdered unburnt limestone, marles, and chalks, have no solvent action upon animal or vegetable remains: on the contrary, they prevent the too rapid composition of substances already dissolved; and they have no tendency to form soluble‖ matters.§ Calcareous matter, in some propor-

* Elements of Agricultural Chemistry, p. 21.
† Ibid. p. 232.
‡ Ibid. p. 21.
‖ Ibid. p. 216.
§ That is to say, not in a direct manner: but where there is any mineral or saline acid in the staple earth or ordinary manure, the radical evil in what is called *sour land*, a top dressing of lime, (see above, I. 1.) will neutralize the

tions, seems to be an essential ingredient in all fertile soils; necessary perhaps to their proper texture, or as a constituent in the organs of plants.*

Although lime, when rendered mild by the recovery of the carbonic acid which was expelled in burning the limestone, does not undergo any further change in itself by continued exposure to the air, yet when saturated with moisture descending in showers or otherwise conveyed to it, it has the property of attracting an additional quantity, or second dose, of carbonic acid: this—not entering into its constitution, but hanging loosely about it by a transient association—the mild lime readily parts with to vegetables growing near; at the same time the bulk of the mild lime is a little lessened by the action of moisture dissolving part of its crust. Lime in every state has also the property of attracting volatile oils floating in the air, as well as fluid oils in contact with it.

The efficacy of a dressing of mild lime is proportioned to the deficiency of calcareous matter in the natural soil. All soils which do not effervesce with acids, are improved by mild lime, and sands more than clays. The rubbish of mortar, on account of the quantity of sand which it contains along with the chalk, is peculiarly fitted to benefit clayey soils. Marle, though the basis of it is mild lime, is to be distinguished from a pure calcareous dressing, because it usually contains the remains of some animal matter, with a little clay or peat.

When a soil which requires an accession of calcareous matter, at the same time contains much vegetable manure, which is already *soluble* by the ordinary agency of moisture and natural heat, without any ingredient that calls for quicklime,—the calcareous dressing should consist of chalk, marle, or mild lime;

acid matter. Quicklime is more efficacious than mild lime for this purpose; but simple chalk, also marle, applied in large quantities, will correct the evil. These manures, by neutralizing the acids combined with the mould, qualify the vegetable and other soluble substances also present, to be converted by the influence of the atmosphere and of moisture into nutriment for plants.—All the experiments yet made render it probable, that the food of plants, as it is taken up from the soil, is imbibed by the extremities of the roots only. Hence, as the extremities of the roots contain no visible opening, we may conclude that the food which they imbibe must be in a state of solution first. And, in fact, the carbonaceous matter, in all active manures, is in such a state of combination as to be soluble in water whenever a beneficial effect is obtained. All the salts which we can suppose to make part of the food of plants, are soluble in water. This is the case also with lime, whether it be pure or in the state of a salt: magnesia, and alumina may be rendered so by carbonic acid gas; and even minute flinty sand may be dissolved in water. We can see, therefore, in general, though we have no precise notions of the very combinations that are immediately imbibed by plants, that all the substances which form essential parts of their food *may* be dissolved in water. *System of Chemistry*, by Thomas Thomson, M. D. F. R. S. E. Vol. V. p. 376. 3d. edit. Edin. 1807.

* Elements of Agricultural Chemistry, p. 21. Compare with "Practical Gardener," p. 601.

and the application of quicklime should be avoided; as quicklime is disposed to unite with the soluble matter of dead plants, destitute of woody fibre, before the latter can have benefited the soil, and thus forms a compound insoluble in water. Quicklime also, while it purifies, diminishes the strength of animal manures; it should never be applied with these, unless they are too rich, or for the purpose of preventing noxious effluvia, as in the cases of reducing carrion, or qualifying night-soil, afterwards mentioned: it is calculated to render soft animal manures less nutritive, and to make oily matters insoluble.*

Quicklime is also injurious when mixed with any common dung, and tends to render the extractive matter insoluble. Further, when it unities with oily matters, it produces a soap not easily dissolved, like the less tenaceous compound formed by mild lime.

Limestones that contain flinty or clayey particles, are not so good as others for burning into lime; but they possess no noxious quality.

Bituminous limestones contain a fraction of coally matter, never amounting to one-twentieth. They make good lime: and the coally matter, so far from injuring land, may, under favourable circumstances, be converted into food for plants.

Nothing yet has been said in regard to UNBURNT LIMESTONE. In a district where limestone is plentiful, and fuel scarce, a farmer, anxious to leave no local resource neglected, might naturally fall upon the idea that lime, in an uncalcined state, if reduced to powder, or ground into small calcareous gravel, would be beneficially applied as a manure where mild lime would be serviceable, without being aware that the same practice had been already partially tried.

The first attempt to convert unburnt limestone into a manure, was made by Lord Kames: no account, however, is known to be extant, from which we can learn how far it succeeded; and the trial must be supposed to have proved abortive, if made upon moss or moorish lands, which, owing to the great quantity of imperfectly decomposed vegetable remains imbedded in them, cannot possibly be benefited by any substance possessing less activity in destruction than caustic lime.

Many years afterwards a large machine was erected in the county of Perth, which was furnished by three pounding-instruments of iron from the Carron Foundry, worked by a stream of water, for breaking unburnt lime into small rubble. This machine was unfortunately carried away by a flood before the effects of such lime as a manure could be decisively appreciated; but as far as the intervening time allowed of experi-

* Elements of Agricultural Chemistry, p. 218.

ments, the conclusions were favourable. Much of it had been expended on a farm of Colonel Alexander Robertson.

As the theory of the thing, those who are sanguine in recommending a farther trial of it, suppose that unburnt limestone must be more powerful in its effects than mild lime, which has gone through the double process of burning and conversion into chalk. Any given quantity of raw limestone, say they,—a bushel, for instance.—contains twice as much calcareous earth as the same bulk of slaked lime. Further, it is commonly imagined by persons who have used both kinds, without making any accurate experiments, that the effects of the raw limestone are slow, but more lasting; of the calcined limestone, more expeditious, but not so permanent. But they seem to overlook the true grounds of comparison. Limestone, in burning, loses, it is true, considerably in weight by the carbonic acid gas which is expelled: Lime, in passing from a caustic to a mild state, recovers this gas from the atmosphere; but it does not regain the qualities of hardness and cohesion; and differs from what it originally was, as powdered chalk from marble, or nearly so, according to the texture of the fossil burnt. Unburnt limestone, therefore, has neither the solvent activity of quicklime,—nor the absorbing power of chalk,—nor the minute division of mild lime mixed with earth, while an impalpable powder.

Time of laying on Lime.—Nothing has been said of the stages in husbandry at which the application of lime is most beneficially made: because this is quite distinct from an inquiry into the principles on which the good or ill effect of lime on different soils can be accounted for. Indeed it depends on considerations which the gardener and agriculturist, each alone in his own province, is qualified to weigh, from an intimate knowledge of their respective lands, and by the professional experience gained in raising the intended crops. Nevertheless, in the valuable collection of Papers which conveys the gathered wisdom of the school of Scottish agriculture, some information occurs on this subject, which it may be useful to disseminate, as marking the general lines of a successful practice.

"In the best cultivated counties, lime is now most generally laid on finely pulverized land, while under a fallow, or immediately after being sown with turnips. In the latter case, the lime is uniformly mild; in the former, quicklime, as pernicious to vegetation, may be beneficial in destroying weeds. Sometimes mild lime is applied in the spring to land, and harrowed in with grass-seeds, instead of being covered with the plough; and under this management, a minute quantity has produced a striking and permanent improvement in some of the hill pastures of the south-eastern counties. Its effects are yet perspicuous, after the lapse of nearly half a century. In some places, lime is spread on grass

land, a year or more before it is brought under the plough; by which the pasture in the first instance, and the cultivated crops subsequently, are found to be greatly benefited. But in whatever manner this powerful stimulant is applied, the soil is never exhausted afterwards by a succession of grain-bearing crops, a justly exploded practice, which has reduced some naturally fertile tracts to a state of almost irremediable sterility."*

3. MAGNESIA in a caustic state (burnt magnesian stone) is pernicious to vegetation: mild magnesia is in no respect hurtful, provided there is a deficiency of calcareous matter in the soil. Caustic magnesia, applied to lands charged highly with rich manure, in a proportion not exceeding one-fifth of the animal or vegetable remains, is speedily rendered mild by the carbonic acid with which it is supplied, as the manure decomposes: but it should never be thrown on land where a portion of quicklime already occupies the surface; because, while the quicklime is becoming mild by its readier attraction for carbonic acid, the magnesia retains its caustic property, and acts as a poison to most plants. Caustic magnesia will destroy woody fibre the same as quicklime; and in combination with strong peat, assists in forming a manure. If the peat equal one-fourth of the weight of the soil, and the magnesia do not exceed $\frac{1}{20}$th, the proportion may be considered as safe. Where lands have been injured by too large a quantity of magnesian lime, peat will be an efficient remedy. See also above, 1. LIME AS A SOLVENT.

Magnesian limestones are usually coloured brown, blue, or pale yellow: they are found in the counties of Somerset, Leicester, Derby, Salop, Durham, Northumberland, and York: they are abundant in many parts of Ireland.†

4. PHOSPHATE OF LIME.—This is a compound of phosphoric acid and lime, one proportion of each; it is insoluble in pure water, but soluble in water containing any acid matter. It forms the greatest part of calcined bones. It exists in most excrementitious substances; and is found both in the straw and grain of wheat, barley, oats, and rye; and likewise in beans, peas, and tares. In some places in these islands, it exists in a native state, but in very small quantities; it is generally conveyed to the land by the medium of other manure; and is probably necessary to corn crops, and other white crops.‡ In soft peats, or other lands which contain an excess of vegetable matter, phosphate of lime is one of the most serviceable manures. See IX. 6.

5. GYPSUM, SELENITE, or SULPHATE OF LIME, is found native at Shotover Hill, Oxfordshire; and abounds in many other parts of England. Natural gypsum commonly consists of wa-

* General Report of the Agriculture of Scotland, &c.
† Elements of Agricultural Chemistry, pp. 220, 221.
‡ Ibid. p. 228.

ter, sulphuric acid and lime; 22 parts of water, 46 of sulphuric acid, and 32 of lime. When the water is expelled by heat, the other constituents keep their proportion unaltered. As a manure, it is the subject of much difference of opinion. It may unravel some perplexities, and conduce to a fair estimate, if we treat of it under the four following heads:

1. Theory of its Operation.—Gypsum meets in few soils any thing which can decompose it; and while its elements remain fixed, it neither assists the putrefaction of animal remains, nor the decomposition of manure. The ashes of particular sorts of peat contain a considerable quantity of gypsum; some kinds, a third part: and such ashes have been applied with good effect as a top dressing for cultivated grasses. In correspondence with this, the ashes of sainfoin, clover, and rye-grass, afford considerable proportions of gypsum: but only a very minute quantity of it is found in barley, wheat and the turnip. The reason why the artificial mixture of gypsum with soils is not generally efficaceous, is probably, because most cultivated soils contain sufficient quantities of it for the use of the grasses, and an excess of it above what other crops absorb in their growth. Gypsum is contained in stable dung, and in the dung of all cattle fed on grass; and it is not taken up in corn crops, or crops of pulse, and in very small quantities in turnip crops.

It is possible that lands which have ceased to bear good crops of *cultivated grass*, may be restored by a dressing of gypsum.* As to a general standard for the application of gypsum, those plants seem most benefited by its application which always afford it on analysis: such as lucerne, clover, and most of the artificial grasses: But where the soil already contains a sufficient quantity of this substance for the use of the grasses, its application even on pasture cannot be advantageous: for plants require only a determinate quantity of manure; an excess may be detrimental, and cannot be useful.†

It has lately been asserted, on the authority of a gentleman resident at Pittsburgh, in Pennsylvania, that gypsum is only useful as a manure in those parts of the United States that are distant from the sea not less than eighty miles. On the hypothesis that sea-air destroys the fertilizing principle in gypsum, Mr. R. Bakewell, a correspondent of the Monthly Magazine,‡ proceeds to account for its failure as a manure in so many parts of England. It is enough to dispel this opinion to name the county of Kent, as the place where it has most fully succeeded.

Sir H. Davy in directing our attention to the constituents of this manure, the composition of the soil, and the nature of the plant, has contributed material aids for judging when to apply

* Elements of Agricultural Chemisty, p. 224.
† Ibid, 19.
‡ For October, 1815.

it:—But perhaps he has not adverted sufficiently to the inimitable chemistry of Nature, by which she may disengage the elements of gypsum when buried in a suitable soil, and enable particular plants to extract them in a simpler form. It therefore becomes important to recollect, that the *sulphuric acid*, which lodges in gypsum in a solid state, can be resolved into—*sulphurous acid gas*, about 40 parts; and oxygen, 60 parts; and that when the water suspended with the two gases is dissipated, the proportions will be nearly,

Condensible into sulphur - - - - - -	16 parts.
Oxygen - - - - - - - - - - - -	64
Water - - - - - - - - - - - -	20
	100

Now, instead of confining the possible benefit to such plants as afford gypsum in an unaltered state, may we not conclude that a large number of vegetables, constituted to reject the calcareous base altogether, may appropriate some modification of the other elements? "The saline compounds (as professor Davy in another place notices) contained in plants, or afforded by their ashes, are very numerous. The *sulphuric acid*, combined with potassa, or *sulphate* of potassa, is one of the most usual. Compounds of the nitric, muriatic, *sulphuric*, and phosphoric acids, exist in the sap of most plants." In analogy with some late experiments of De Saussure, we may further suppose that sulphuric acid, diluted with water by the chemistry of Nature, may be instrumental in converting the starch of plants into sugar. "As starch boiled in water with sulphuric acid, and thereby changed into sugar, increases in weight without uniting with any sulphuric acid or gas, or without forming any gas, we are under the necessity of ascribing the change solely to the fixation of water. Hence we must conclude, that starch-sugar is nothing else than a combination of starch with water in a solid state. The sulphuric acid is neither decomposed, nor united to the starch as a constituent; nevertheless it is likewise found that long boiling in pure water does not convert the starch into sugar."* This fact opens a large field for rational speculation on the physiology of vegetables; as it renders it possible that some of the mineral acids in the sap of plants, after acting chemically on the juices concocted into pulp, may be thrown out unchanged: they may alter the flavour without entering into the essence of the fruit.

Another step in the process of conversion brings us to pure *sulphur*. Some plants yield this on analysis. Seeds, sown by way of experiment on nothing but this mineral, have produced

* See a Translation of the original Paper in *Annals of Philosophy* for December 1815. (No. XXXVI. pp. 425, 426.)

healthy plants; and many soils, which nature has impregnated with sulphur, are highly fertile.

The peats or loams on which gypsum has been most successful, may contain vegetable acids calculated to decompose it. It is true that the means by which human art can at present separate its elements are very limited. It is decomposed, 1. by the oxalic acid; 2. by carbonates of potash; 3. by carbonate of strontian; 4. by muriates of barytes. The second and third solvents are only mentioned to be dismissed, as unlikely to be of any use in agriculture: the *carbonate* of lime generated by the second, being less soluble in water than the *sulphate;* and chalk, when wanted, can be had at a cheaper rate. The third, carbonate of strontian, is a newly-discovered earth, of rare occurrence. As to the compound produced by the fourth, sulphate of barytes is perfectly insoluble in water: and it is a reasonable suspicion that it would be pernicious to vegetable life.

To recur to oxalic acid, the first-mentioned solvent. This is naturally present in wood-sorrel, and is procured artificially by the action of nitric acid upon sugar, and several other vegetable substances. Peat-moss, in an unreclaimed state, usually abounds with oxalic acid: hence there is a mutual action between that sort of peat and gypsum. Perhaps such a compound might be cheaply imitated, by mixing vegetable mould and wood-ashes, urine and gypsum; or short muck, old cow-dung, sea-weed, and gypsum,—substituting, where sea-weed cannot be obtained, soap-lye; or bleacher's lees; or salter's refuse, vegetable ashes, and water.

It may be worth while also to try, whether in those cases where quicklime would form an insoluble compound, or diminish the nutritive richness of a compost, gypsum may not be a capital ingredient; for instance, with some of the following substances: *oily matters;*—*animal acids;*—all *animal manures*, particularly such as contain *albumen*, (one element in the white of eggs is sulphur;)—the common *dung of cattle.*

Furthur, as mild lime and gypsum seem to be as unlike each other as two substances with the same base can well be, it may be of practical benefit to compare their effects in various composts of the same strength.

To close this theoretical part, sulphuric acid has a great attraction for water, and may be useful in a soil in summer. Where the sulphur cannot be decomposed, it may diminish the coldness of some lands. Gypsum may be offensive to delicate aphides by the same impregnation; and it may kill some hardy insects by setting into a hard crust upon them.

In addition to the common case of land being already saturated with gypsum or lime, are there any descriptions of soil on which decomposed gypsum might have a bad effect? 1. Would it not deteriorate a soil containing particles of iron? This may

be put as a caution; for sulphate of iron is pernicious to vegetation; but as lime is the antidote to that vice in a soil, decomposed gypsum seems, even in this case, to contain its own remedy, unless the proportion of lime be thought too low. 2. Might not the sulphuric acid hurt the texture of a soil almost wholly composed of pure clay? Sulphate of alumina is not baneful to plants as a salt, though, as a mineral earthy compound, it is not the most tractable under tillage: but here again lime is present, to prevent its formation, or to dissolve it.

II. Experience of it abroad.—It is about half a century since gypsum was discovered to have IN PENNSYLVANIA almost a magical influence on the growth of red clover; and it is there held in rising estimation. The Pennsylvanian farmers seem to have derived from Europe the first suggestions for applying this manure to artificial grasses. M. Gilbert, from whom a quotation is given in Sect. IV., states the practice to have long prevailed in France with signal success. In Germany, Mr. Mayer, a clergyman, discovered the use of gypsum as a manure about the year 1768; and in Voghtland, in Saxony, gypsum-earth is said to have converted several barren tracts into fruitful fields. The agriculture of Switzerland has also reaped much benefit from the same resource.

III. Experience of it in this Island.—Perhaps it has not yet received a fair trial here; but as far as experiments in different counties of England and Scotland are reported, the mass of evidence is against it.

[As the FIRST EXPERIMENT of Arthur Young relates to a particular point in the "Method of Preparing and Applying it," it is given under that head.]

SECOND EXPERIMENT *by the* EDITOR *of* ANN. AGRIC.

"*Marked five square Rods of Clover on a good Turnip Loam with a gravelly bottom, worth* 10*s. an acre, in March,* 1791.

"No. 1. Sprinkled with one quart of gypsum.
2. Two quarts.
3. Three.
4. Four.
5. Five quarts of wood ashes.

"Nos. 1 and 2 were equal, and rather superiour to any of the rest. No. 5. was the worst. The clover manured (compared with the adjoining land that had no manure) was not only considerably higher, but thicker, of a deeper and more luxuriant colour, and of a broader leaf.

"One quart to a rod, is five bushels to an acre. I am confident that neither such a quantity of night-soil, pig-dung, peat-ashes, nor any other manure with which I am acquainted would have had an equal effect. The result of this experiment is therefore quite contrary to that of last year.* A. Y."

EXPERIMENT *by* JOHN ALLEN, *Esq. on four square Rods, First Year's clean Clover.*

Nos. 1 and 4. No manure.
No. 2. Four quarts of sifted cinder-ash which had never been exposed to the atmosphere.
No. 3. One quart of gypsum.

* Annals of Agriculture, Vol. XVI. p. 184.

When the clover was in full head, all being mown, the produce of Nos. 1 and 4. averaged 38 *lbs.* 6 *oz.* each.
No. 2. weighed 50 *lbs.*
No. 3. 54 ½ *lbs.**

Another gentleman, Mr. R. Procter Anderdon, of Henlade, Somerset, after detailing some trials, says,—"Hence I conclude, as far as my experiments go, that on many plants, or on many soils, gypsum powder will have no effect; but that it has an effect on old clover, on a loamy soil; and that a greater effect may be reasonably expected from it, when applied to younger plants of the same sort."†

From a subsequent Letter of the same Correspondent, it seems greatly to promote the growth of Chicory, and to be destructive to the slug.

A farmer, near Epping, in 1791, found it greatly to increase the returns from a sowing of oats.

The extensive experiments made by a Kentish farmer, in the years 1792, 1793, and 1794, are reported in the *Bath Papers*, vol. VIII. The first states generally that they were chiefly upon "light loams and poor calcareous soils, especially of the chalky kind." It is therefore very important that the following observation, which occurs in detailing a particular experiment, should have a conspicuous and prominent place. "A light loamy earth to the depth of three feet on chalk, produced much better crops, than a shallow surface on chalk, both having been manured with gypsum." The plants were chiefly sainfoin, cow-grass, and Dutch clover; and repeated trials were attended with favourable results.

To these might be opposed many instances of the failure of gypsum as a manure, in various parts of England, even when applied to grass-lands: but the failures uniformly consist, not in any pernicious effect, but in the want of any superiour returns, compared with unmanured lands of the same quality.

Whether it is that in North Britain the farmers find it more profitable to pare off peat, and use it as a compost for lands under tillage, than to attempt the reclaiming of entire beds of soft peat by immediate cultivation,—or whether they have cheaper top-dressings,—the sum of their experience in regard to gypsum, is expressed in the following sweeping conclusion: "Gypsum has not hitherto been attended with any success in Scotland."‡ As to grass-lands not abounding in vegetable remains, what has been stated under head 1. makes it less surprising that a dry powder, so hard to decompose, should not have produced any effect corresponding to its reputation in America.

* Annals of Agriculture, vol. XVI. 303.
† Ibid. vol. XVII. p. 297.
‡ General Report of the Agricultural State on Scotland, vol. II. p. 537.

IV. Method of preparing and applying it.—Even those writers who maintain that there is nothing like gypsum, pointedly differ in their instructions for preparing and applying it. One in the opposite hemisphere says: "The spring of the year has been esteemed the best season for sowing it; but I have sown it in March, April, May, June, July, August; and I know no difference in its effect. You will observe, it is only a top manure, therefore must be sown on a sward of grass: it is particularly good for white and red clover. It may be broken by hand, and afterwards sifted; but we stamp it, and afterwards pass it through our mill-stones: IT MUST NOT BE CALCINED"* . . . . . "Six bushels to the acre I use, and it is preferable to fifty loads of the best dung. This you must think extravagant; it is so, and yet true."†

M. Gilbert, author of a *Treatise on Artificial Grasses*, published in France,‡ says, that "it produces the same effect WHETHER IT IS CALCINED OR ROUGH, if it is but powdered; that six bushels, Paris measure, manure very well an acre for a year; and that half that quantity does for the two following years. The only thing to be attended to, is, not to sprinkle this manure before the seeds which are mixed in the herbage are near ripe: if sowed sooner, it makes the trefoil grow so fast as to smother the grass with which it is mixed . . . . . It only produces beneficial effects when sowed after or before rain; sowed on dry land which continues such, its effects are nothing."

As to CALCINING: It is not likely to make any difference, because the sulphuric acid in gypsum cannot be expelled by the most violent heat of the furnace; and an experiment of Arthur Young§ countenances the assertion, that the effects of gypsum are the same, whether calcined or rough. It is thus stated:

"*Spots were staked out on an upland meadow of clover.*

No. 1. A perch uncalcined. The grass weighed, green, 112 *lbs.*
No. 2. Calcined. 114 *lbs.*
No. 3. No manure. 113 *lbs.*"

The produce is uncommonly great; but the equal success of the unmanured piece makes this experiment a comparative failure.

The American farmers employ it upon *new ground*, and strew it upon the surface. In reclaiming a peat not already disposed to form sulphate of lime, it may qualify an excess of *soft* vegetable matter very beneficially. It does not follow, however, that on lands differently circumstanced, particularly upland

* Extract of a Letter from Philadelphia, dated Sept. 16, 1788. *Annals of Agriculture*, vol. XV. p. 109,
† Ibid. June 1, 1790, p. 110.
‡ Reviewed in *Annals of Agriculture*, vol. XV. p. 444.
§ Annals of Agriculture, vol. XIV. p. 319.

pastures, which seem to be worn out, the same mode of application ought to be adhered to; and if a restorative is sought in gypsum, the history both of its successes and its failures, would recommend a compost containing peat, or some imitation of it. This will be a fair test of what it can effect.

6. Burnt Clay.—Of late, very flattering reports have been circulated of the practice of burning clay into ashes, for a top dressing. It is not a recent invention: for very particular instructions for doing it are given in a small Treatise, published near a century ago.* Revived lately in Scotland, the process, described in a letter by Mr. Craig, has excited much attention, and induced many spirited agriculturists, in various parts of the island, to adopt it on a large scale. The expectations from it are sanguine; although the experience had of it is not yet extensive enough to form a ground of recommending it for general application. It is called "Burning Clay for Manure: yet, as the torrefied powder is not valued for any vegetable ashes supposed to be contained in it, as in the common practice of paring and burning, but is simply to operate as burnt earth, it were more correct to modify the term to "Burning Clay to improve the Texture of the Soil." This is not a verbal distinction, but a practical difference. If attention to it should much contract the field for the operation, it may prevent many disappointments. Thus, suppose the agriculturist is induced, from his system of farming, to cultivate turnips on a clayey soil, not well adapted to their growth, it is plain that the ashes of burnt clay, copiously distributed over the surface, would immediately consult the habits of the plant, by dividing a tenacious, and rendering drier a humid soil; and thus, without supposing the burnt clay to act as a manure, the texture of the staple would receive a permanent improvement. On the other hand, if on a soil not rich in the common basis of vegetables, and which is to be planted with any of the exhausting culmiferous crops, or other crops dependent on a generous soil, the panacea of mere burnt earth is resorted to, as a substitute for the long tried proportions of consumable manure, the result of such an ill-timed application of fire must be disappointment.

Indeed the operation of burning clay for ashes is so tedious and expensive, that even where the circumstances of the land demand such an improvement, the outlay would overwhelm the farmer—unless he intermit the practice during those stages of rotation in which he can raise beans, and other crops fit for clay

* *The Practical Farmer; or, the Hertfordshire Husbandman.* See a Letter in the *Farmer's Magazine,* No. LXIII. with the signature "J. G. F." It is also mentioned in *The Country Gentleman's Companion,* by Stephen Switzer, Gardener. (London, 8vo. 1732.) This latter work states, that the Earl of Halifax was the inventor of this resource: and it gives several letters, written in 1730 and 1731, attesting its success in several parts of England; with accounts from Scotland that it had answered better than lime or dung!—but was found too expensive.

soils, by easier modes of tillage. If, however, he is satisfied to prepare land, by this practice, for the green crop, or other stage of a rotation which most requires it, and is attentive at other times to keep up the vegetable strength of the staple by soluble manures adapted to repair the exhaustion of preceding harvests, and to meet the appetite of the expected crop, the texture of the soil will be gradually improved, while the danger of relying upon burnt earth as a manure will be avoided. If the surface burnt is a peat, or moss, or contains the roots or other remains of plants, the ashes may be truly a manure; but then the principle and its application are assimilated to the practice of paring and burning turf, and the useful commerce in peat ashes; neither of which is a novelty. So a marl, fraught with animal remains, is decidedly a manure.

The clay may be either burnt in heaps, or in kilns. For this purpose, it is dug or pared off in shallow spits, about four inches thick. Two layers of these are commonly taken. Whether any part of the subsoil should or should not be also dug up, depends upon its composition. See above, Sect. IV. It accelerates the process of ignition to set the spitfuls first to dry, either separately or in open piles. The kiln may be fired with furze, wood, cinders, coal, or any combustible refuse. As to the quantity of ashes to be applied, the *Hertfordshire Husbandman* says,—"About forty bushels, sown on an acre by the hand, out of the seed-cot, and harrowed in with barley and grass seeds, does vast service." The Scottish agriculturists assign from twenty to twenty-five cubic yards per acre, as a dressing for turnips.

When kilns are used, limestone may be burnt with the clay.

If this practice be combined with that of burning with lime instead of fire, the expense will be lessened, and a manure of better composition obtained. It may be acceptable to describe a good method of doing both together.*

Pare off the sods, or turf, and surface clay, with the skim-coulter plough, or other convenient instrument, and dry the parings ready for burning. Get quicklime fresh from the kiln in the following proportion: having marked out a base for the pile, for every square superficial yard, three Winchester bushels of lime; or for a mound seven yards in length, three yards and a half in breadth, 72 bushels. In building, begin with a layer of dry parings, six inches in height; on which spread half the lime intended to be used, about five inches thick, mixing sods with it; then a covering of eight inches of sods; on this the other half of the lime is spread, and covered a foot thick; the height of the mound at this stage being about a yard. Mr. Curwen deems it better to suffer it to ignite of itself, than to effect the combustion

* The following is derived from the Letter of Mr. Curwen, of Workington-Hall, to Mr. Dempster, of Dunichen, published, by permission, in the *Farmer's Magazine*, No. LXIV. p. 411.

by applying water. In twenty-four hours it will take fire. When the fire is fairly kindled, fresh sods must be applied. Mr. C. recommends obtaining a sufficient quantity of ashes, before any clay is put upon the mounds. The fire naturally rises to the top. It takes less time in piling, and effects more work, to draw down the ashes from the top, and not carry the mound higher than six feet. The clay if not sufficiently burnt is lumpy, and untractable under tillage: on the other hand, Mr. C. regards calcined ashes as of no value; but they ought certainly to be burnt to a powdery state, or until they will fall to powder from a slight stroke; and it does not appear that the calcination of any earth lessens its absorbing power. The finer clay-ashes are, the greater is their capacity of absorption from the atmosphere.

Some idea may be formed of the spirit with which Mr. C. has taken up the trial of this system of surface-soil and clay-burning, when he says, "I have just completed paring twenty-six acres of clover lea of the second crop, which I intended next year for turnips. The sods were well broken with the harrows, which freed them of the greatest part of the mould. The residue was burnt, and has afforded me above a thousand single-horse carts of ashes. There are twelve mounds with seventy-two Winchester bushels of lime each.....I have manufactured for use this season, two thousand single carts of ashes."

On lands thus manured, while turnips and clover have, in the most favourable cases, surpassed expectation, wheat has fallen below it. At present the balance of experience from the recent trials seems to have this inclination: the advantage of burning clay alone is questionable, as a measure of *general application;* and unless vegetable matter or lime is burnt with it, the benefit will seldom repay the expense. When clay has been burnt alone, dung, or other manure containing vegetable nutriment, should be spread with it, especially in preparing land for an exhausting crop.

Many discoveries in tillage fall into disrepute by being applied without regard to local circumstances, or by being continued after a sufficient change has been effected in the original constitution of the soil. Burnt clay can only be what physicians would call a topical remedy.

VIII. *By introducing Mineral or Saline Elements as Manures.*—Mineral substances are more or less contained in decayed animal or vegetable matters. When these substances have been extracted in a pure state, by a chemical process, they are in general too expensive and too useful in the arts or in the ordinary affairs of life, to be applied as manures: on which account the following experiments will serve rather to shew the principle or cause of a fertilizing, or contrary effect, from the *gross matters* in which they are found, than for the purpose of expending the pure extract on any soil, as in the ex-

periments: on the other hand, it will appear, from some of the details under this article, why an earthy mass, or heap of refuse matter, containing a particular chemical substance, may be beneficial,—while that substance in a pure state is pernicious.

1. COMMON SALT, or MURIATE OF SODA.—The Mineral Alkali of Soda is the basis of Marine Salt. "When common salt acts as a manure, it is probably by entering into the composition of the plant in the same manner as gypsum, phosphate of lime, and the alkalies. It has been proved to have been sometimes useful in small quantities. It is likewise offensive to insects. Some persons have argued against the employment of it, because, when used in *large* quantities, it either does no good, or renders the land sterile; but this is not a cause for entirely rejecting it. In Cornwall, the refuse salt from the large works of dry-salters—which, it is to be remembered, contains some of the oil and scales or other parts of the juices and skins of fish—has long been known as an admirable manure. But as latent muriate of soda is one of the constituents in almost every kind of animal and vegetable manure, the cultivated lands of these islands may be supposed to contain, in general, a sufficient quantity for the purposes of vegetation, (not to mention that the surrounding sea must have an effect on the air and soil to a considerable distance inland;) so that a direct supply of it to the soil may be found, in most cases, not only useless but injurious.* In the water given to plants which are natives of the sea-coast, a minute infusion of common salt would consult the natural circumstances of that description of vegetables: indeed they languish without it.†

2. COMPARATIVE EFFECT OF DIFFERENT SALTS.—Professor Davy confirms and illustrates the above and affords a general principle for the solution of contradictory results under altered circumstances, by an experiment on the effect of different salts conveyed in water to the roots of plants.

The subjects of trial were separate spots in a garden, on which grass and corn were growing. The soil of the place was a light sand,—of which 100 parts contained 60 of flinty sand, 24 of finely divided earth or chemical elements of earth, and 16 of vegetable matter; and of the whole, less than one part in 100 was saline matter, principally common salt. The saline substances tried were *super-carbonate of potassa*, (crystals of soda,) *sulphate of potassa*, (vitriolated tartar,) *acetate of potassa*, (foliated earth of tartar,) *nitrate of potassa*, (prismatic nitre,) and *muriate of potassa; sulphate of soda*, (glauber's salt or vitriol of soda;) *sulphate*, *nitrate*, *muriate* and *carbonate of ammonia*. The quantities applied were two ounces to each spot

* Elements of Agricultural Chemistry, p. 230.

† *System of Chemistry*, by Thomas Thomson, M.D. F.R.S.E. vol. V. p. 364, 3d edit. Edinburgh.

twice a week. In all cases where the quantity equalled $\frac{1}{30}$th part of the water, the effect was injurious; but least so in the instances of the carbonate, sulphate, and muriate of ammonia. When the quantities of the salts were $\frac{1}{300}$ of the solution, the effects were different:—Then, the plants watered with the solutions of the sulphates grew just in the same manner as similar plants watered with rain water: Those acted upon by solutions of nitre; acetate, and super-carbonate of potassa; and muriate of ammonia; grew rather better; those treated with the solution of carbonate of ammonia grew most luxuriantly of all: The plants watered with the solution of nitrate of ammonia did not grow better than those watered with rain water; "probably (says Sir H. Davy,) the free acid had a prejudicial effect, and interfered with the result." But if the effect was equal to that of rain water, there was no proof of a pernicious agency; the ill effect was merely negative, and seems rather to have prescribed a slight increase in the quantity dissolved in the water.

IX. *By Manuring with Refuse Substances not excrementitious.*—Heaps of refuse matter, which contain excrementitious substances incidentally, and but in a small proportion, will be included under this article.

1. Street and Road-Dirt and the Sweepings of Houses may be all regarded as composite manures. As they are derived from different substances, their constitution varies; but in all cases they refresh and strengthen a soil. Scrapings of roads not clayey are beneficial without exception: those from high-roads are enriched in far the greater degree by the droppings of cattle. The promiscuous dung which is gradually incorporated with the sludge, is so perfectly reduced by exposure to the weather, that it takes the appearance of earth. The effects of road-drift are in many cases beneficial in a higher degree than the cultivator might expect from its known composition: but the greatness of the benefit may be well accounted for, by considering that the gravel, or slate, or stone, which is ground into earth by the passing of carriages along a road, is necessarily *virgin-earth*, having never been in a state to support vegetation. Fine road-stuff is better than dung on pasture land.

2. Soot is a very powerful manure; its great basis is charcoal, in a state of solubility by the action of air and water. It contains also salt of ammonia, with a portion of oil. To mix soot with quicklime is a bad practice; because much volatile alkali is thus disengaged, without any benefit to the land. This manure requires no preparation; and is well fitted to be used in a dry state, as a top-dressing (a peck to four square poles of land) thrown in with the seed. It is a good improver of cow-dung and goose-dung; either of which alone, and in a fresh state, are of little power. Further, its alkali tends to make oily particles miscible with water.

3. Coal-Ashes.—It appears from an experiment of Mr.

Wright, afterwards particularly adverted to, that coal-ashes on a plot where barley is to be grown has the same efficacy as hog-dung; while it is inferior to the dung of sheep, and something better than that of horses.

4. Coal-Water, or the liquor produced by the distillation of coal, is said to be a good manure.

5. Wood-Ashes consist principally of the vegetable alkali united to carbonic acid: and as this alkali is found in almost all plants, it may be an essential constituent in the organs of the greater part. The vegetable alkali has a strong attraction for water. See the comparative efficacy of wood-ashes with that of coal-ashes and the dungs of several kinds of cattle and domestic fowls, under X. 6.

6. Carbonate of Ammonia.—The liquor produced in the distillation of coal at the Gas Establishments, may be recommended as a valuable manure on the following accounts. First, it principally contains carbonate of ammonia; (see the experiments by professor Davy already sketched:) secondly, it contains also a little sulphur. In the proportion of one gallon to 16 or 18 of water, this liquor may be applied to all green crops as a manure, with good effect. When the object is to destroy insects, three gallons only of water should be added to one of the liquor.

7. Coal Tar.—The tar produced in making carburetted hydrogen gas is beneficial as a manure, conveyed in proportionate heaps of earth or marle. One gallon of this tar being mixed with about a wheelbarrow full of mould or fit earthy materials, will form a compost of great activity. This may be either ploughed in or used as a top-dressing, as the nature of the land and crop may render expedient.

8. Bones consist of phosphate of lime and decomposable animal matter. Bone powder, bone shavings, and bone ashes, are serviceable where phosphate of lime is to be supplied to a soil. Bone ashes ground to powder will impart a reduced share of benefit to arable lands, containing much vegetable matter, and may perhaps enable soft peats to produce wheat; but powdered bone, in an uncalcined state, is always to be preferred to bone ashes, because the oil and other animal matter with which bones are richly charged has not been dispelled.

9. Horn is still a more powerful manure than bone, as it contains a larger quantity of decomposable animal matter:* it is very durable in its effects on a soil.

10. Hair, Feathers, and Woollen Rags, are all analogous in composition; they are more nearly allied to horn than to bone; they contain a great quantity of albumen (a substance similar to white of egg,) gelatine (basis of jelly,) with some oil. Woollen rags act powerfully for one year.

* Elements of Agricultural Chemistry, p. 198.

11. REFUSE OF SKIN AND LEATHER, accumulating in different manufactories—such as furriers' clippings, the shavings of the currier, and the offals of the tan-yard, and the glue-maker—form highly useful manures; any one of which, buried in the soil, operates for a considerable time.*

12. BLEACHER'S WASTE.—It is usual to cast away the residuum of the stills as a worthless article: but surely if some competent person were employed to separate the *sulphate of soda* from the sulphate of manganese, the former might be turned to a good account. The waste solutions of the *oxy-muriatic salts* are also convertible into a valuable manure. See the experiments of Professor Davy, above. Humboldt, about 1810, discovered that a weak solution of such preparations, has the property of accelerating and enlarging the growth of vegetables. Gardeners whose grounds are in the neighbourhood of bleach-fields, would do well in availing themselves of all the advantages their situation affords them for making experiments on this interesting and important subject.† The waste lees, after boiling linen yarn or cloth, may also be used for alkalizing composts.

13. SOAPER'S WASTE has been recommended as a manure, under, the supposition that its efficacy depended upon the different saline substances which it contains: but the quantity of these is very minute indeed; its chief ingredients are mild lime and quicklime, either of which, when a supply of calcareous materials, or when a caustic solvent is wanted in a soil, may be had at a cheaper rate.

14. The FLUID, or DISSOLVED PARTS, of ANIMAL SUBSTANCES, require some preparatory process to fit them for manure. The great object is to blend them with the soil in a proper state of minute division. When these have been applied in a rank or unreduced state, bad effects have followed. Perhaps *while they retain the combinations of animal matter unchanged, or not entirely broken, they are ill adapted to promote the functions of vegetable life.* Thus tallows and oils, received in a crude state by the roots, may clog the pores of the bloated plant, repel dews and aqueous fluids, and obstruct the free communication of the leaves with the atmosphere.

One mode is, to spread the animal fluid thinly on the land under tillage, and *previous to putting in the seed or plants*, to suffer the free escape of the volatile particles that will go off by exhalation. The better mode is to convey animal matter in a compost of earthy or vegetable materials.

BLOOD is a good manure. The SCUM taken from the boilers of SUGAR-BAKERS consist principally of *bullocks' blood.*

When sugar-baker's waste has been reduced to the finest state

* Elements of Agricultural Chemistry, p. 199.

† *Chemical Essays*, by Samuel Parkes, F. L. S. London, 1815. vol. IV. p. 160.

possible, it will still be improper for application as a manure, until it has been mixed and incorporated with three or four times its bulk of some earthy substance, which may be enriched with a proportion of vegetable mould or desiccated dung.

GRAVES also are too rank both for corn and grass, unless conveyed in a compost of earthy materials; wood ashes may be profitably added, as having a tendency to divide and correct the particles of tallow.

OILY SUBSTANCES contain a deal of carbon, and are employed as manures with great advantage. Animal or vegetable alkali increases their fertilizing power, by converting them into soaps. Quicklime diminishes their efficacy, tending to make them insoluble.—TRAIN-OIL and BLUBBER. All the practical writers on the application of train-oil and blubber, and similar refuse, agree that to rectify it, it must be made into a compost with a great body of earth, though they may recommend different proportions under the diversified circumstances on which individual experience is founded.

The ingenious Dr. Hunter* advises a compost thus formed; Let 12*lbs.* of American potash be dissolved in four gallons of water: mix the solution with twenty bushels of dry mould, and fourteen gallons of train-oil.

A Correspondent of the *Farmer's Magazine*† found that blubber in a crude state, as he applied it in a first essay, destroyed, instead of assisting, vegetation. Twelve years' experience has led him to a most successful method of using it, which he presents to the notice of other agriculturists. His plan is to make it into a compost in the proportion of nine loads of earth to one load of blubber. He first makes a layer of earth two feet thick, —building it a foot higher at the sides, three feet inward, like a solid wall, to form a cavity for the blubber. When the blubber has been laid on a foot in depth, similar layers are repeated to a convenient height till the blubber is expended, leaving three feet of earth for the top layer: The entire heap is then beat down close at the top and sides to exclude the air. In this state it will ferment, and the earth becomes impregnated with the foul air of the blubber. When this fermentation abates, which it will do in about two months, the heap is to be turned over from top to bottom. The bottom layer of earth, which thus becomes the cover, will require some addition in thickness, to prevent the escape of air by the second fermentation: When this abates, the compost is again turned over; and after a third fermentation, becomes fit for use. The communicator of this method then adds: "The mixing or applying lime therewith, I have found detrimental, as the lime reduces the blubber, and prevents fermentation. I never use this compost until it is nine or twelve

* *Georgical Essays.*

† No. LXIII. (dated Aug. 7, 1815,) p. 287.

months old. In this state, I have applied—to both grass and tillage land—about 10 or 15 loads of the compost per acre, each load weighing two tons; and have cut from the grass land three tons of hay per acre, and after-grass in proportion. I have also used it to tillage crops of wheat, beans, and potatoes, on a field of 20 acres, that has not been fallowed for ten years, until this present summer, but manured annually in the above proportion; and from which I have reaped five quarters of wheat per acre,—five quarters of beans,—and from 1300 to 1500 pecks of potatoes,—with those crops in succession. The land is a strong clay; and the only difficulty from constant cropping is in keeping it clear from short twitch grass, of which if left in the land, the blubber encourages the growth."

Pulverized OIL-CAKE has been used with advantage as a manure: it is an antidote to the wire-worm, especially if mixed with elder or wormwood, when it proves a certain means of destroying the worm; an effect which is explained by reflecting that oil is destructive to most insects. A mill has been invented for pulverizing oil-cake as a manure, which, with one horse, will crush five tons per day.

15. REFUSE FISH forms an excellent manure, provided the quantity be limited,—and, that sufficient time intervene, before the plants are put in, for the combinations of animal matter to be destroyed. In an instance, recorded by Mr. Young, of too great a quantity of herrings having been ploughed in for wheat, so rank a crop was produced, that it was entirely laid before harvest. In order to prevent a dressing of fish from raising too luxuriant a crop, they should be mixed with earth, or sand, and sea-weed. Their effects are perceptible for several years.

"The manure produced in the fishing villages from the mixture of all oily and fishy substances, favours bear [barley] and green crops; but when used much, renders the soil unfit for producing oats: hence that soil is called poisoned."*

16. CARRION is not commonly used as a manure, though there are many cases in which such an application might easily be made. Horses, dogs, sheep, deer, and other quadrupeds, that have died accidentally or by disease, are too often suffered to lie exposed to the air, or immersed in water, till they are devoured by birds or beasts of prey, or entirely decomposed: meanwhile, noxious gases are given off to the atmosphere, and the land where they lie is not benefited. By covering a dead animal with six times its bulk of soil, mixed with one part of lime, and suffering it to remain for a few months, the decomposing carcase is made to impregnate the superincumbent mould with soluble matters, so as to render the compound an excellent manure; and by mixing a little quicklime with it at the time of

* Sinclair's *Statistical Account of Scotland*, vol. VII. p. 201.

its removal, the disagreeable effluvia would be in a great measure destroyed. Any waste carcase may also be dissolved by enclosing it in a heap of vegetable matter in a state of fermentation: but it is advisable to urge and sustain the fermentation at a heat high enough to kill gentles and caterpillars.

17. RAPE-SEED CAKE, composed of the husks or bran of rape-seed, is a restorative manure for arable land. It should be used when fresh, and turned in with the seed.

There is also a rape-cake formed of the ashes from burnt rape-straw, which contain a deal of alkali. This is a good dressing for turnips.

18. MALT DUST is a manure of great power and vivacity. It answers best as a spring top-dressing. Provide for wheat ten quarters per acre; barley, eight; grass-land, four. It excels in stimulating a cold soil.

19. SEA WEED.—In some of the maritime counties a great deal of sea weed comes in on the shore. This manure is transient in its effects, and does not last for more than a single crop. But for one crop it has been found to be the most productive of any.* It is sometimes suffered to ferment before it is used: but this seems wholly unnecessary; for there is no fibrous matter rendered soluble in the process, while a part of the manure is lost. The best farmers use it as fresh as it can be procured. Where it cannot be immediately applied, a good resource to save the juices draining from it is to lay it on a flattened heap of earth preparing for compost.—Sea-weed, as a manure, improves the growth and taste of esculent herbs.

20. DRY STRAW and SPOILED HAY, with every sort of haulm, is convertible into manure for all lands. In general, such substances are made to ferment before they are employed; "though it may be doubted (says Sir H. Davy) whether the practice should be indiscriminately adopted. There can be no doubt that the straw of different crops immediately ploughed into the ground affords nourishment to plants: but there is an objection to this method, from the difficulty of burying long straw, and from its rendering the husbandry foul. When straw is made to ferment, it becomes a more manageable manure: but there is likewise a great loss of nutritive matter. More manure is perhaps supplied for a single crop: but the land is less improved than it would be, supposing the *whole of the vegetable matter could be finely divided and mixed with the soil.* It is usual to carry straw that can be employed for no other purpose to the dunghill to ferment and decompose: but it is worth experiment, whether it may not be more economically applied when chopped small by a proper machine, and kept dry till it is ploughed in for the use of a crop. In this case, though it would *decompose much more slowly*, and

* Sinclair's *Statistical Account of Scotland*, vol. VII. p. 202.
† Elements of Agricultural Chemistry, p. 194.

produce less effect at first, yet *its influence would be much more lasting.*"*

On this question, and the proposed artifice for preserving the whole quantity of refuse straw or hay as manure for the soil, the Reader's attention is invited to the Strictures and Suggestions annexed to the article, MANAGEMENT OF MANURE FROM THE HOMESTEAD.

21. VEGETABLE MOULD, or tree-leaves decomposed, is a manure so nearly fit for universal application, that no other exception need be made to it than the case of a soil being already too rich. It is too valuable to be used on common occasions, alone. It may be mixed with sand, perfectly rotted dung, exhausted bark, or other ingredients, according to the wants of the soil.

22. WOODY FIBRE.—"Mere woody fibre (says Professor Davy) seems to be the only vegetable matter that requires fermentation, to render it nutritive to plants.

"TANNERS' SPENT BARK is a substance of this kind. Mr. Young, in his Essay on Manures, which gained him the Bedfordian Medal of the Bath Agricultural Society, states that, '*spent bark seems rather to injure than to assist vegetation;*' which he attributes to the astringent matter that it contains. But, in fact, (remarks the Professor) it is freed from all soluble substances by the operation of water in the tan-pit. If injurious to vegetation, the effect is owing either to its agency upon water; or more probably, to its mechanical structure and effect, being very absorbent and retentive to moisture, and yet not penetrable by the roots of plants."†

By 'Tanners spent Bark,' in the above passage, it is to be understood only the bark from which the tanning principles has been extracted in a tanner's vat. This substance, *when fermented*, as directed under "Hot-house," in Abercrombie's "Practical Gardener," is a great auxiliary to vegetation: in general, the excitement from it is only safely given through the medium of mould; but the offsets and cuttings of many plants, struck into the surface of a bark-bed, will vegetate without earth. See "Pinery," and Grape-house." With regard to its application in the open garden, it is not a fit dressing for common beds, till reduced to an earthy state.

INERT PEATY MATTER is similar, in respect to the absolute necessity of fermenting it before it can be beneficial as a manure. It remains for years exposed to water and air without undergoing change; and, in this state, yields little or no nourishment to plants. Lord Meadowbank has recommended a mixture of farm-yard dung for the purpose of bringing peats into fermenta-

* Elements of Agricultural Chemistry, p. 194.
† Ibid.

tion; for this end, dung is well adapted, but any putrescible substance will serve equally well; and the more readily any refuse litter heats, the better will it answer the purpose. In ordinary cases, one part of dung is sufficient to decompose three, and from that to six, parts of peat: green vegetables, mixed with the peat, will accelerate the fermentation. In the height of summer it will take about three months—and in the season comprehending winter, six months—to reduce fermented peat to the state of vegetable mould. Ten cubic yards per acre may be ploughed in for wheat.

Shavings of Wood, and Saw-dust, will require as much dung, or green vegetable refuse, to bring them into fermentation, as the worst kinds of peat.

The fibre and grain of wood can be much sooner decomposed by the action of caustic lime, than by the process of fermentation. The young shoots of pruned trees, and similar vegetable refuse, may be speedily converted into a manure, by being laid in a pit, with alternate layers of quick-lime. Mr. Brown, of Derby, has been honoured with a medal, from the Society of the Adelphi, for this contrivance, extending the application of a principle which has been immemorially known, and recently much adverted to. See above, Lime as a solvent.

23. Ashes of vegetables not woody.—The conversion into ashes by combustion of vegetable refuse matter, otherwise easily reducible into manure by fermentation, may sometimes increase its fertilizing power in one of these ways: either by augmenting the tendency in the manure to produce carbonic acid, under the combined action of charcoal, moisture, and air, —or by the effect of the alkali in relation to some other manure, or the texture of the soil,—or by some ingredient which would be pernicious in combination being expelled in the burning. Vegetable ashes, applied as a top-dressing, may also contribute to the destruction of insects and their larvæ.

Burnt Straw is said, by an intelligent practical farmer,* to be a manure that will insure a crop of turnips. The comparative efficacy of burnt straw is shewn by an experiment of Mr. Wright, recorded in a subsequent page.

Peat Ashes have a local utility as a top-dressing for cultivated grasses. The peat ashes of Berkshire and Wiltshire, in particular, are sold at a considerable price for manuring artificial grass-lands, and are much celebrated for their good effect. Professor Davy, having analysed as well these ashes as the soils to which they are successfully applyed, found in the soils themselves no sensible quantity of gypsum;† the ashes, on the other hand, consisted in great part of gypsum, with a little iron, a little common salt, and variable quantities of calcareous, alu-

* *A General View of the Agriculture of the East Riding of Yorkshire*, by H. E. Strickland, Esq.

† Elements of Agricultural Chemistry, p. 19.

minous, and siliceous earth, and sulphate of potassa. But such is not generally the case with peat ashes: to produce this preponderating quantity of gypsum, the peat must be charged with vitriolic matter, and lie on a substratum of calcareous earth.—Turf-ashes are used in the Netherlands for manuring clover and other grass lands; and force great crops.

X. *By Excrementitious Substances applied as Manure.*—The potency of dung as a manure varies with the animal affording it.

1. Dung of Sea-birds.—One of the most powerful dungs is that of such sea-birds as feed on animal food. The naturally sterile plains of Peru are fertilized by *guano*, a species of dung collected from small islands in the South Sea, frequented by sea-birds. It is used over a great extent of South America, applied in very small quantities, and chiefly for crops of maize.

The dung of sea-birds had not been used in this country as a manure until a trial of it was made in Wales, at the recommendation of Sir H. Davy; in which instance it produced a powerful but transient effect on grasses. That sagacious and candid experimentalist hence conjectures, that the rains in our climate materially injure that species of manure, unless where it happens to be deposited in caverns or fissures of rock, out of reach of the weather.

2. Night-Soil, in whatever state used, whether recent or fermented, is a very powerful manure, and capable of supplying abundant food to plants. Saw-dust is a good vehicle for it. The disagreeable smell of night-soil may be destroyed by mixing it with quick-lime; and if exposed to the atmosphere in thin layers, strewed over with quick lime, in fine weather, it speedily dries, and is easily pulverized: so prepared, it may be used in the same manner as rape-seed. The Chinese mix their night-soil with one third of its weight of a fat marle, make it into cakes, and dry it by exposure to the sun. These cakes, which are said to have no disagreeable smell, form an article of commerce. In the neighbourhood of London, this manure is prepared for sale in a concentrated state, so as to be inoffensive in the carriage, even when conveyed in bulk. The Compressed Night-soil may be commodiously used as a top-dressing for wheat in the spring of the year, and for all kinds of spring corn, for young clovers, and other green crops; one hogshead will be sufficient for an acre, when it has been prepared with due attention to the preservation of its fertilizing properties. As an enriching manure, many experiments have established, that human ordure is to be ranked many degrees before the dung of the pigeon, hen, sheep, or swine; powerful as all these are. But its effects are not so permanent as those of many other substances. From recent experiments, Mr. Middleton concludes, that no other manure can compete with it for the first year after its application; in the second year, the benefits from it are very much diminished; in the third, its effects, nearly, if

not quite, disappear. Much depends on the depth of soil. There can be no doubt that a substance in which the principle of vegetable nutriment is highly concentered, is in proportion well calculated for speedily restoring or enriching land, and for forcing great crops without detriment,—supposing the staple to be deep enough for tillage, and to be fitly constituted as to texture. On the other hand, a shallow dip of mould requires contributions of new earth, without which forcing manures will but exhaust it sooner.

On the authority of trials which seem to be convincing, some writers have insisted that an inconceivable loss of valuable fluid is incurred by exsiccating night-soil. Though this may be a good reason for forming this substance into a compost with earth, where it can be consumed on the spot; yet it is none against the use of the article in a concentrated state, in which the loss, as far as the escaping fluids are not transferred to some absorbent compost, falls upon the preparer; while the expense of carriage, in regard to the solid essential part, is materially lessened.

3. Pigeon's Dung is next in fertilizing power. When dry, it may be employed as other manures capable of being pulverized. One tenth part of pigeon's dung, four parts of sand, and five parts of vegetable mould, is a good compost for a cold heavy soil.

The following interesting quotation must recommend pigeon's dung as a fine ingredient in a compost for melons. "The produce of the sub-district of Linjan (in the province of Irak) is not inferior to that of the most fertile spots in Persia. This sub-district is about seventy miles in length and forty in breadth: it is irrigated by canals cut out from the Zeinderood, and covered with villages, which are surrounded with gardens and prodigious numbers of pigeon-houses. On inquiry I found that these birds are kept principally for the sake of their dung, and that the acknowledged superiority in the flavour of the melons at Ispahan, is alone to be ascribed to this rich manure. The largest of the pigeon-towers will sell for three thousand pounds; and many of them yield to the proprietors an annual income of two or three hundred pounds each."*

4. The Dung of Domestic Fowls approaches very nearly in quality to pigeon's-dung. It is very liable to ferment.†

Sir Humphrey Davy here ranks the dung of domestic fowls next to pigeon's dung, without defining what species of fowls is intended, or discriminating between the different kinds of domestic fowls. It appears from a set of comparative experiments recorded in the Agricultural Magazine, that Hen dung,

* *Geographical Memoir of the Persian Empire*, by John Macdonald Kennier. Political Assistant to Sir John Malcolm, in his Mission to the Court of Persia, 4to. London, 1813. p. 110.

† Elements of Agricultural Chemistry, p. 204.

or the dung of the common fowl, is most efficacious; Duck dung is to be rated second; while Goose dung was found so inferior that the produce from a spot manured with it was not much above the average of three patches sown without manure. See the statement at length, under article 6.

5. RABBIT'S DUNG has been used with great success as a manure; so much so, that it has been found profitable to keep rabbits chiefly for the sake of the dung, and to have the hutches constructed in subservience to the object of accumulating it without waste.

6. The DUNG OF CATTLE.—"Of the dung of cattle (says Sir H. Davy,) that of hard-fed *horses* appears to be the strongest. The dung of *sheep* and *deer* is thought to be more efficacious than that of oxen. The dung of *oxen* is supposed, by many, to require a long preparation to fit it for manure.

To combat the opinion that ox-dung requires a long preparation, Sir Humphry then enters upon a course of argument against the general practice, in regard to fermenting promiscuous dung-heaps. "If the dung of cattle is to be used as a manure, like the other species of dung which have been mentioned, there seems no reason why it should be made to ferment except in the soil; or if suffered to ferment, it should be only in a slight degree. The grass in the neighbourhood of spots where unfermented dung has been dropt, is always coarse and dark green: some persons have attributed this to a noxious quality in unfermented dung; but it seems to be the result rather of an excess of food furnished to the plants."

The estimate founded on the experiments adverted to under article 4. above, does not correspond with the order in which the dung of horses and that of sheep are mentioned by Sir H. Davy; and it countenances the objection held in common by many practical men against the use of fresh cow-dung. Nine different kinds of manure having been tried on patches of barley, the result was as follows:—

Hen-dung.....Most efficacious.
Duck-dung.....Second in power.
Sheep-dung.....Third.
Coal-ashes. } ...Exactly alike. Fourth
Hog-dung. }
Horse-dung.....Fifth.
Wood-ashes.....Sixth.
Goose-dung.. { Seventh. Not much above the average of three patches sown without manure.
Cow-dung.....Evidently prejudicial.

The quality of the land is not stated; but possibly one cause of the cow-dung being prejudicial, was the natural coldness of the soil. Moreover, barley is extremely impatient of dung that is not well digested and divided. But on warm arid soils, cow-dung may be an improving manure, if fermented with other

dung, or kept alone till it can be pulverized. In canvassing this point with an eminent horticulturist, he informed me, that it is his own practice, and that of many gardeners skilled in preparing choice composts, to keep cow-dung for a period of three years, before they apply it either alone as a manure, or as an ingredient in a composite mould. When used in a fresh state, as a manure, it should never be alone, but mixed with any such articles as the following, of a warm nature, and easily pulverized: the dung either of the sheep, the hog, the horse, the rabbit, the pigeon, the hen, the duck, with some of the animal manures; or with lime and sand, marle, soot, coal-ashes, the ashes of any burnt vegetable, or other substance; as the soil may want either to be strengthened, or to be cooled with as much cow-dung as can be applied without its peculiar disadvantages. Properly qualified, it is a good dressing for most shrubs and fruit-trees.

As the texture of the soil varies, or as a plant of a different nature forms the crop, so the proportion of fertilizing power which a comparative trial of manures has fixed in one instance will vary in another. Still some manures seem to be universally inferior; while others, though not always standing in the first place, may be relied on for conducing to a profitable return. A paper by the Rev. James Willis, President of the Christ-Church Agricultural Society, records two valuable experiments, made to ascertain the positive effect of *different* manures on the product of potatoes, in the same soil, with the same sort, and under the same management. One experiment was on the *eyes alone*, or small cuttings; and the other on the *whole root;* so that the increase from these also may be compared. The sort planted was the WHITE ROUND, on a clean sandy loam, well pulverized, in rows two feet asunder, twelve inches distant in the row, and six inches deep.

TABLE *of* EXPERIMENTS *with the* EYES *only, planted on the* 12th *April* 1810.

MANURE.	PRODUCT.
1. Pig's dung	1 bag and half, *per lug*.
2. Mown grass	1 bag and 2 bushels.
3. Sheep's dung	1 bag and 1 peck.
4. Coal-ashes	1 bag and 1 peck.
5. Hen's dung	1 bag and 1 peck.
6. Old rags	1 bag 2 gallons.
7. Garden rubbish	1 bag 1 gallon.
8. Horse-dung	1 bag 1 gallon.
9. Turf-ashes	1 bag 1 gallon.
10. Turf-dust	1 bag.
11. River mud	1 bag.
12. Cow dung	1 bag.

TABLE *of* EXPERIMENTS *with the* WHOLE ROOT, *planted on the* 10th *April* 1811.

MANURE.	PRODUCT.
1. Pig's dung	1 bag 3 pecks, *per lug*.

MANURE.	PRODUCT.
2. Sheep's dung	1 bag and half.
3. Coal-ashes	1 bag and half.
4. Old rags	1 bag and half.
5. Mown grass	1 bag, 2 bush. 2 pecks, 1 gall.
6. Hen's dung	1 bag 2 bushels.
7. River mud	1 bag 1 bushel.
8. Turf-ashes	1 bag, 3 pecks, 1 gallon.
9. Horse-dung	1 bag 3 pecks.
10. Garden rubbish	1 bag 3 gallons.
11. Turf-dust	1 bag 3 gallons.
12. Cow-dung	1 bag 3 gallons.

On reviewing the two Tables, we may perceive, that though the relative powers of the manures may vary a little, from accidental causes, yet the increase from the Whole Root, as tried against that from the Eyes with the same manure, is uniformly so much greater as to prove decisively that it is more profitable to set either a Half or Whole Root, than to plant Eyes. The author of the Experiments also informs us, that in digging up the potatoes, he found those produced from the eyes much smaller.

To the passage above quoted (p. 68,) Sir H. Davy subjoins: "The question of the proper mode of the application of the dung of horses and cattle, however, properly belongs to the article of *composite manures*; for it is usually mixed in the farm-yard with straw, offal, chaff, and various kinds of litter; and itself contains a large portion of fibrous vegetable matter." See next section, MANAGEMENT OF MANURE FROM THE HOMESTEAD.

7. HOG-DUNG—according to the comparative statement above, (p. 68,) ranks immediately after sheep-dung, and before horse-dung.

8. URINE.—All urine contains the essential elements of vegetables in a state of solution: but the various species of urine from different animals differ in their constituents; and the urine of the same animal alters when any material change is made in its food. During the putrefaction of urine, the greatest part of the soluble vegetable matter contained in it is dissipated: it should consequently be used as fresh as possible; but if not mixed with solid compost, it should be diluted with water; as when undiluted, it contains too much animal matter to form a proper fluid nutriment for absorption by the roots of plants. Putrid urine abounds in ammoniacal salts; and though less active than fresh urine, is a very powerful manure.*

MANAGEMENT OF MANURE FROM THE HOMESTEAD.

COMPOSITE MANURE.—Under the head X. 6. it has been noticed, that the consideration of the right mode of applying the

* Elements of Agricultural Chemistry, p. 201.

Dung of Cattle, on a large scale, belongs to the article *Composite Manure;* because it is mixed in the farm-yard with straw-litter, and with various kinds of vegetable offal, which itself contains a large proportion of hard fibrous matter.

The remarks scattered in the Elements of Agricultural Chemistry on this subject are thrown together in the following abstract.

Professor Davy's Theory on Composite Manure.

A slight incipient fermentation is undoubtedly of use in the dunghill; for by means of it a disposition is brought on in the woody fibre to decay and dissolve, when it is carried to the land, or ploughed into the soil,—and *woody fibre is always in great excess in the refuse of the farm.* Too great a degree of fermentation is, however, very prejudicial to the composite manure in the dung-hill: it is better that there should be no fermentation at all before the manure is used, than that it should be carried too far. This must be obvious, from the following considerations. The Professor's arguments may be arranged under five heads: four theoretical; and one practical.

1. "An immeasurable quantity of substance disposed for conversion into food for plants is then suffered to escape in the form of drainings and vapour. During the violent fermentation which is necessary for reducing farm-yard manure to the state in which it is called *short-muck*, not only a large quantity of fluid, but likewise of gaseous matter, is lost; so much so, that the dung is reduced one-half, and from that to two-thirds or more in weight: now the principal elastic matter disengaged is carbonic acid with some ammonia; and both these, if attracted by the moisture in a soil, and retained in combination with it, are capable of becoming nutriment to plants."—In aid of this reasoning, the Professor relates an experiment, from which he considers that he has obtained particular proof that the gaseous matter from fermenting dung is of great utility to growing plants. He introduced the beak of a retort filled with fermenting manure, consisting principally of the litter and dung of cattle, into the border of a garden among the roots of some grass. In less than a week, a very distinct effect was produced upon the spot exposed to the influence of the matter disengaged in fermentation; the grass grew with much more luxuriance than in any other part of the garden.

II. "There is (continues the author of the experiment) another disadvantage in the loss of *heat;* which, if excited in the soil, is useful in promoting the germination of the seed, and in assisting the plant in the first stage of its growth, when it is most feeble and liable to disease; and the fermentation of manure in the soil must be particularly favourable to the wheat

crop, in preserving a genial temperature beneath the surface, late in the autumn, and during winter."

III. "Again, it is a general principle in chemistry, that in all cases of decomposition, substances combine much more readily at the moment of their disengagement than after they have been perfectly formed. And in fermentation beneath the soil, the fluid matter is applied instantly, even whilst it is warm, to the organs of the plant; and consequently is more likely to be efficient than in manure that has gone through the process of fermentation, and of which all the principles have entered into new combinations."

IV. The Professor, in another place, reminds us, that the ultimate results from an excess of fermentation in a heap of manure are like those of combustion.

V. "A great mass of facts may be found in favour of the application of farm-yard dung in a recent state. Within the last seven years, Mr. Coke has entirely given up the system of applying fermented dung; and he informs me (says Sir H. Davy) that his crops have been since as good as ever they were, and that his manure goes nearly twice as far."

VI. *Objection noticed by the Professor.*—Sir Humphry then candidly states an objection made by many practical Agriculturists to his system for managing composite manure. "A great objection against dung but slightly fermented, is, that weeds spring up more luxuriantly where it is applied."

To which he answers: "If seeds are carried out in the dung, they certainly will germinate; but it is *seldom* that this can be the case *to any extent:* and if the land is not cleared of weeds, any kind of manure, fermented or unfermented, will occasion their rapid growth."

VII. *His own Practical Application of the above Theory.*—It is to be observed, that the Professor admits the beneficial tendency of a slight or incipient fermentation in mixed heaps. To regulate the practice of fermenting composite manures, as the basis of the heap may vary, these are his two general principles: 1. Whenever manures, consist principally of matter SOLUBLE IN WATER, their fermentation or putrefaction should be prevented as much as possible. 2. The only cases in which putrefaction can be useful, are when the manure consists chiefly of animal or vegetable FIBRE.

Agreeably to the above principles, Sir H. Davy then gives *Directions for the Management of Farm-yard Dung in the Heap, and for its Application to the Soil:* of which the following is the substance.

"Where farm-yard dung cannot be immediately applied, the destructive fermentation of it should be prevented as much as possible. For this end, the dung should be kept dry, and unexposed to the air; for moisture and contact with the oxygene of

the atmosphere tends to excite fermentation. To protect a heap from rain, a covering of compact marle, or of a tenacious clay, should be spread over the surface and sides of it.*

"Watering dunghills is sometimes recommended for checking fermentation: but this practice, although it may cool the dung for a short time, is inconsistent with just views; for moisture is a principal agent in all processes of decomposition: dry fibrous matter will never ferment.

"If a thermometer plunged into the dung does not rise to above 100° of Fahrenheit, there is little danger of much aëriform matter flying off. If the temperature is higher, the dung should be immediately spread abroad.

When dung is to be preserved for any time, the *site* of the dunghill is of great importance. In order to have it defended from the sun it should be laid either under a shed, or on the north side of a wall. To make a complete dung repository, the floor should be paved with flat stones, a little inclination being made from each side towards the centre: in the centre there should be drains, connected with a small well, furnished with a pump, by which any fluid matter may be collected for the use of the land. It too often happens that the drainings of the dunghill are entirely wasted."

The Professor then adverts to the application of littery dung on pastures. "If slightly fermented farm-yard dung is used as a *top dressing for pastures*, the long straws and unfermented vegetable matter remaining on the surface should, as soon as the grass begins to rise vigorously, be removed and carried back to the dunghill: in this case no manure will be lost, and the husbandry will be at once clean and economical."

Free Remarks on the Theory, and on its Practical Application.—Having finished the above compendium of Sir H. Davy's Views on the Management of Manure from the Homestead, the Writer subjoins a few Strictures and Suggestions in regard to the five principal grounds on which the Professor recommends that composite manure should be, under common circumstances, but slightly fermented before it is spent on land.

The first objection of the Author of the *Elements* to the reduction of farm-yard dung to the state of *short-muck*, relates to the loss of FLUID, and of GASEOUS matter.

Every person must admit that the subtraction of a fluid substance from a mass of dung must diminish the strength and richness of the intended manure; and though in some cases the bulk of the fluid may be rain water or waste water accidentally falling upon the dunghill, yet it cannot be denied that part of the essence of the dung must be carried away in the drainings. Nevertheless, where the drainings of the dunghill can be saved in

* Elements of Agricultural Chemistry, p. 208.

a proper receptacle, in order to be applied to heaps of dry compost, or to land under tillage, there is no loss to the Agriculturist in the separation of the fluid part of the manure.

Sir Humpry Davy's plan of a well to catch the drainings of a dunghill is sufficiently practical; and where the nature of the tenure makes it worth the cultivator's while to have such a well, is perhaps as good a method as can be devised for obviating the loss of fluid matter.

In other cases, where a reservoir cannot be formed for the drainings from an accumulating mass of dung, it will be a serviceable expedient to prepare a thick layer of good earth (cultivated mould or rich loam,) raised at the edges as the basis of the intended dunghill: which layer of earth, by continually receiving the moisture draining from the superincumbent dung, will be as valuable for manure, when the whole is removed as the dung itself.

The escape of GASEOUS matter forms another part of the objection to fermenting dung, above cited from Sir H. Davy. Under a previous head, IMPROVEMENT OF SOILS, V. *By Fallowing*, the writer, in endeavouring to meet a speculative objection to fallowing, founded on the escape of gaseous matter, has offered some considerations why that should not be estimated as a loss. (p. 28. 31.)

As to the escape of gaseous matter from fermenting dung, it is not easy to prevent it, if the dung lie any where but in the very bosom of the land. Perhaps, however, when dung must be partly decomposed before it is applied, a case of mould over the heap would attract, and hold in combination, much of the carbonic acid and ammonia which would else escape in vapour. Such mould, like that laid underneath, would be imbued with sustenance for plants, but in a less degree, and only in proportion to the completeness of the fermentation. But the covering of earth, would in some instances be liable to be burnt, and in others be apt to prevent the free fermentation necessary to dissolve woody fibre.

As to the experiment of the vapour directed from the beak of a retort on some grass growing in a border, as recorded by the Professor; it may be in place to observe, that the effect on grass, of which the species is not mentioned, fails to afford a sufficient criterion:—had the subject of experiment been a kitchen esculent requiring a rich soil and yet impatient of rank manure, and had the trial been protracted till the time of flowering or fruiting, some satisfactory conclusion might have been formed with regard to the influence of the gas on the growth of the plant and the flavour of its edible produce.

The second objection to the fermentation of a heap of dung intended for manure, at a temperature exceeding 100 degrees of Fahrenheit as a maximum, adverts to the loss of HEAT. The

way in which the loss of heat is supposed by the Professor to operate, involves so much that is hypothetical, that an appeal to the result of trials in which the different causes that may operate are not distinctly measured will not be decisive in favour of the theory; because it frequently happens that an effect which pretty constantly attends a particular practice is attributed to the wrong cause. Now it appears contrary to nature, and to the principle on which a warm climate is imitated in any forcing department, to excite the roots of a plant with any degree of artificial heat, unless there be some cover or weather-screen to detain the warm vapour and create an atmosphere corresponding to the soil; and the seed or root ought to be protected from the fermenting substance by a coat of earth.

The disadvantage from the loss of heat in manure may therefore be more correctly attributed to the entire exhaustion of the fermenting principle, and to the want of its influence in communicating a kindred fermentation to dry fibrous matter already in the clod, and so reducing it to a state of aliment for plants. On the other hand, it may conduce to the health and vigour of the plants to have the fermentation in the soil completed before the new crop is put in, so that the growing roots may not be in contact with putrefying substances.

The third ground of argument for postponing the decomposition of manure till it be imbedded in the soil is drawn from a principle in chemistry, that SUBSTANCES ESCAPING FROM DECOMPOSED BODIES ENTER INTO NEW COMBINATIONS MOST READILY WHEN FIRST DISENGAGED. There seems no reason for contesting the practical inference deducible from this principle —provided the intention be confined to promoting the combination of the matter disengaged from the dissolving body intimately with the soil: either by casing the dunghill with mould to be used as compost, or by burying the manure in a clod when partially fermented, and before it is much exhausted of the rudiments of vegetable matter by drainings or vapour; taking care to have the manured soil afterwards properly turned and exposed to the air before it is sown or planted, so that whatever gaseous matter has a natural tendency to fly off into the air may freely escape. But the theory on which a beneficial influence is anticipated from applying the "fluid matter while it is WARM to the organs of the plant," seems to be repugnant to the process of nature, and closely allied to that hypothetical branch of the second ground of argument already objected to. Nor is there any proof that a fermenting substance is fit food for a living plant: the residuum of animal and vegetable substances purified by free exposure after decomposition seems, in the circle of natural operations, to contribute chiefly to the bulk of new plants: but when crude animal or vegetable remains, or the fluid or solid substances rejected in the composition of animals, are administer-

ed to growing plants, the rank manure appears, from numerous experiments, to make them flourish unnaturally at first, and then to induce disease and premature decay. To give an instance from each class, this is the known effect of oil, tree-leaves, urine, night-soil.

The utmost extent of the fourth objection will bring the dung which has casually *fire-fanged* on a par with the ashes of various burnt vegetables. How far the condensed power of these (a specific sort being chosen for the desired effect) has been found on particular soils cropped with suitable plants, to exceed that of the very same sort of manure in an unfermented state, or in any stage of decomposition short of combustion, is well known to practical cultivators, and has been partly noticed in p. 65. This objection is again adverted to under *Recapitulation*, sect. 5. Fire-fanging, regarded as a mischief, as an excess beyond the farmer's design is easily prevented.

The fifth argument is entirely practical, and the authority adduced in its support one of the highest. If, under different local circumstances, other cultivators are led to the same conclusion by similar experiments carried on for a sufficient course of time, this single argument will have more weight than the other three; because there can be no competition between theory and experience.

It is nevertheless to be observed, that the statement made above, after Mr. Coke, is not clear in its import: it can have the weight just conceded to it only on the construction, either that some of the manure made on the farm that was expended under the old system is disposable for some other purpose under the new,—or that some expense in fetching manure from distant places, that had used to be incurred, is saved: but if the statement, "that the crops are as good as ever they were, and that the manure goes nearly twice as far," mean only that the dung when now expended is nearly twice as much in bulk or weight, and covers the surface of the field more thickly in the same proportion, the benefit is merely illusory,—the crop is confessedly not increased; while the carriage of the dung to the land must be heavier, and the labour of spreading it greater.

The following Experiment of Mr. Wright, recorded in the *Agricultural Magazine*, N. S. No. 3. is a valuable contribution on this subject.

COMPARATIVE EXPERIMENT *on* THREE KINDS *of* MANURE,

And on a Cultivated Soil WITHOUT *Manure:*

Half a Rood of Ground being allotted to each.

SUCCESSIVE CROPS, and PRODUCE, from a single Application of the following *Quantities;* viz.

	Fresh stable dung in a Straw state, 3 Tons.	Rotten Stable Dung Eight Months old, 2 Tons.	Dry Barley Straw Burnt on the Ground, 15 Cwt.	On Ground *Without* Manure.
1st. Crop, *Turnips* - -	18 *cwt.* 6 *st.* 6 *lbs.*	16 *cwt.* 1 *st.* 7 *lbs.*	8 *cwt.* 3 *st.* 7 *lbs.*	1*st.* 8 *lbs.*
2d. Crop, *Barley*, 2 pecks sown on each plot. -	30 bushels 2 pecks *per acre.*	36 bushels 3 pecks *per acre.*	30 bushels 1 peck *per acre.*	14 bushels 3 pecks *per acre.*
3d. Crop, *Clover*, 274 *lbs.* to each half-rood. -	20 *cwt.*	21 *cwt.*	18 *cwt.*	8 *cwt.*
	As to the Feed before and after Mowing, it was about equal to the expense of getting in each crop respectively, with a small surplus for the field manured as in the second column.			
4th. Crop, *Oats*, 2½ bushels to each parcel. -	38 bushels.	40 bushels.	38 bushels.	32 bushels.

To complete this experiment, there wants a notice of proportion of weight which a heap of rotten dung would lose in eight months: three tons of strawey dung would scarcely make more than a ton and a half of completely rotted dung: but when dung is reduced one-third in weight, the fermentation may be considered far enough advanced for agricultural purposes in general.

Supposing the original quantity to have been on a par, the above experiment would be, in every instance but the first, in favour of the rotted dung: the small inferiority in the case of the turnips may be attributed to there being an excess of manure above what the plant required; so that had but one ton been put on for the turnips, and the other ton been reserved for the second crop, the benefit to both crops might have been much enhanced. It appears from the Experiments of Mr. Hassenfratz, cited in Dr. Thomson's *System of Chemistry*, that the times in which manures begin to produce their effects, and the length of time for which they operate, are proportioned to the degree of putrefaction under which they are applied. Having manured two pieces of the same kind of soil, the one with a mixture of dung and straw highly putrefied, the other with the same proportions of dung and straw newly mixed, and the straw almost fresh, he observed, that during the first year, the plants which grew on the putrefied dung produced a much better crop than the other; but the second year (no new dung being added) the ground which had been manured with the unputrefied dung produced the best crop: the same thing took place the third year; after which, both seemed to be equally exhausted. Another experiment of the same chemist made on shavings of wood, places in a striking light the slow progress of the effects of manure which decomposes slowly. He allowed shavings of wood to remain for about ten months in a moist place, till they began to putrefy, and then spread them over a piece of ground, by way of manure. The first two years, this spot produced nothing more than others which had not been manured at all; the third year it was better; the fourth year it was still better; the fifth year it reached its maximum of fertility; after which it declined constantly till the ninth, when it was quite exhausted.

When dung moderately fermented has been applied to land sown with turnips, it has been observed that the fly is not so apt to take the turnip as when the dung has been fermented in a deficient or excessive degree. This is not to be attributed so much to the vapour from the dung being offensive to the fly, for a high heat is congenial to the insect, as to the plants making such quick progress from a free but well-tempered excitement as to get into the rough leaf and past danger before the insect lights upon it.

In the sixth place, the abstract above presented from Sir H. Davy's Lectures, notices a main objection to the expenditure of

dung on land when but slightly fermented, which is, that weeds spring up more luxuriantly when dung in that state is applied. By way of repelling this objection, the Professor merely alleges, that "it can seldom be the case to any extent that seeds are carried out in the dung.

Not to dismiss an important objection without obviating it,—If the system of using composite dung when green, or but slightly fermented, be adopted, the following precautions and limitations seem necessary in collecting the materials. From the dunghill intended to be so expended must be excluded many things naturally mixing in the refuse heaps of a farm and garden. These things may be comprehended under three classes:—1. Weeds; 2. Vegetable remains, containing woody fibre; 3. Particular kinds of dung which are pernicious without being pulverised. But articles which contribute so materially to the mass of vegetable manure need not be lost. Let one dunghill be set apart as a rot-heap for such substances as it is requisite entirely to decompose before they are carried to the land, particularly weeds and woody fragments.

The heap to which litter and dung is carried for use when slightly fermented should be kept at a distance from the rot-heap, and nothing should be admitted into it but what is easily soluble from the effects of heat and moisture.

An intelligent friend named in the Preface to the "Practical Gardener," as a contributor of several valuable additions to that posthumous work of Abercrombie—who derives his opinions on practical points from a long course of experience in the direction of large horticultural and farming establishments, enlightened by a general acquaintance with the best authors on rural economy—has communicated to the Writer several observations in respect to the application of dry litter and unfermented dung on land.

In the above review of Sir H. Davy's system, under the head IMPROVEMENT OF SOILS, IX. 17, "Dry straw and spoiled hay," a method of employing these materials without fermenting is suggested. If the expense of cutting dry straw by a machine to prepare it for manure should not prove too great, it may be worth the cultivator's while to employ it as above recommended on LAND UNDER THE PLOUGH OR SPADE, *provided the soil is rich enough in vegetable aliment to sustain the expected crop without any immediate benefit from the manure.* Manure so applied will rather assist the second crop than the first.

Incontestable Exception. In land to be sown with barley, littery unreduced dung has a remarkably bad effect.

With regard to PASTURES, the agriculturist above alluded to entertains, from experience, from observation, and from reasoning on theoretical grounds, a decided opinion, that neither hay nor straw, nor any haulm, should be applied to the surface of

grass-land before it has undergone a sufficient fermentation to ensure its easy and expeditious decomposition when spread abroad. On grass-land, the object of combining as much as possible of the manure with the soil is more likely to be promoted by spending it in a stage already advancing toward complete decomposition, than by lodging on the ground strawy litter not at all fermented; while the face of the verdure will not be so long encumbered. Nor will the gaseous matter escaping from litter left slowly to rot in a pasture more benefit the land than if it had exhaled from a dunghill in the homestead. It is altogether different in relation to land under the plough or spade: by turning in the manure as soon as circumstances may render fit, when fermentation has just commenced and the long litter is somewhat reduced, the fluid matter is secured for the enrichment of the land without any extraordinary pains and without injury, because the crop is *afterwards* put in: the gaseous matter is also secured; but whether permanently or not, may be doubted, because substances disposed to take a volatile form will fly off whenever the bosom of the soil is opened to the air by tillage.

In order to preserve the fluids draining from dung, without the expense of a reservoir, or the trouble of laying a terrace of mould as the site of a dunghill,—the composite dung or litter, previous to fermentation, may be laid in heaps on the field where it is to be spent, and then brought to ferment by the same means as dung preparing for a hot-bed, and kept fermenting for about the same time before it is spread. This might be done even on pasture: but it is worth consideration, 1°. Whether the spreading of a substance which has to go through the whole process of fermentation over a surface of grass may not materially injure the life or the health of the herb. 2°. Whether a smaller proportion of manure, if laid on pasture in a state approaching that of vegetable mould, may not be more beneficial, by soon mixing with the soil, and doing no injury to the crop, than the larger quantity of litter, which has to lie for a length of time heating and partially rotting before it is dissolved and imbibed by the sward. This is stated as a subject for further inquiry, in deference to the Professor: but a practical farmer who has tried the matter is decidedly of opinion that dung must be considerably reduced to be of unqualified benefit to pasture.

To obviate one principal objection against employing strawy unfermented dung as a *top dressing for pasture*, Sir H. Davy proposes to carry back to the dunghill the long straws and unfermented remnants of vegetable matter. This mode of removing the encumbering litter would be attended with an expense far beyond the value of the strawy refuse: and yet, were such litter left in a pasture after the new herbage shoots, the husbandry would be foul; and, in the loss of manure, with injury to the crop, doubly unprofitable.

With respect to the dung of cattle in a green or unfermented state, it is said, under the head IMPROVEMENT OF SOILS, X. 6. as a quotation from Sir H. Davy: "If the pure dung of cattle is to be used as a manure, like the other species of dung which have been mentioned, there seems no reason why it should be made to ferment, except in the soil."

The first ground of exception to this, is offered by Mr. Wright's experiment already quoted, proving that green cow-dung is pernicious on land sown with barley.

As to sheep-dung, deer-dung, hog-dung, and horse-dung, in a green state, they may be applied, either singly or mixed, to ploughed land in general with a good effect. The hot and fiery kinds of dung should not be laid on pasture, unless tempered by mixture with the colder sorts, or unless the quantity applied can be minutely divided so as to facilitate both the equal distribution of it over the field, and its speedy sinking into the surface.

Thus the dung of hard-fed horses should not be used green on pasture land, because of its heating quality; but it may be turned into ploughed land with obvious advantage. If, however, an arable field is in want of instant benefit from manure, such part of the manure as consists of horse-dung ought to be fermented; because the dung of an animal not chewing the cud contains much undigested matter,—straws of grasses, or grains of corn, according to its food, broken into small parts, but not dissolved: whereas the dung of most cattle that ruminate soon putrefies in the soil. Cow-dung alone forms an exception; some of its peculiarities are noticed below.

Sheep's dung may be applied green, either to pasture or ploughed land. The urine of sheep, richer than that of other cattle, except perhaps deer, is of equal utility with their dung. The dung of deer is as well adapted to improve pasture without long encumbering the surface, as that of sheep. If sheep are folded, the sooner the dung is ploughed into the land the better.

Neat's dung in a recent state is cold. Another cause of its bad effect alone is its tendency to cake, so that it has a tenacity like that of clay: hence it is not easily pulverized, so as to be equally distributed over a field, and intimately blended with the soil. When laid pure in a mass, it does not naturally heat; but it may be brought to ferment by a mixture of straw and hot dung. If kept for a long time unmixed with other dung, it undergoes a change within itself, without losing the vegetable part of its substance by fermentation. When the dung of oxen is prepared as the main ingredient for exotic fruit-bearing shrubs, it should be kept for three years by itself, to lose its tenacity: after which period it is full of aliment for plants, perfectly

divested of that rankness which is offensive to the roots of trees, and easily pulverized.

Where several dung-heaps are collected near a homestead, it may be proper to distribute the litter to each, with some attention to the kind of crops for which the manure is to be spent. Stable dung, also the straw of corn and pulse crops, might be set apart to augment the bulk of manure preparing for arable land: offal hay, the sweepings of the hay-loft, and the decayed substance of green crops, would revert, with much fitness, in the shape of compost, to fields of pasture. This is only an extension of the principle on which malt-dust has been employed as a manure for barley, with peculiar success. Lands laid down under grass merely to prepare them for corn should be treated when manured as arable, in respect to the quality of the manure, especially when on the point of being broken up.

The following practical outlines on important points in the Management of Manure from the Homestead are drawn from a recent work of great authority, to which we have more than once appealed. As far as they correspond with communications already given, it is a satisfactory corroboration: if they manifest any shade of repugnance to practices or opinions detailed in this treatise, the circumspection of the Reader will be usefully awakened.

"In the Southern counties of Scotland at the present time, the crops are cut very low: the straw and haulm is used for absorbing the excrementitious matter of domestic animals. The juices of the dunghill are carefully preserved from waste; while the heap is greatly augmented and enriched by the consumption of green clover and turnips, and made to undergo a greater or less degree of fermentation and putrefaction according to the crops and soils to which it is to be applied. Dung is never laid on foul land,—very rarely on pasture or hay grounds, as in England; but it is distributed economically over a third or fourth part of the land in tillage, and thus over the whole farm in regular succession, at a time when the soil is in a state to receive the greatest benefit from its operation, and in that stage of a rotation when the land most demands that method of recruiting it.

"For a drilled turnip crop, it is indispensable that the dung be well rotted, and capable of instantly hastening the growth of a plant which in its infancy is exposed to the attack of several deadly enemies. But an abundant crop of potatoes may be raised by the use of fresh unfermented manure; and for clay soils generally, whether the manure be applied to a fallow under

preparatfon for an autumn sowing of wheat, or for beans, as it has a much longer time to decompose in the soil, a less degree of putrefaction is required than for a turnip crop."*

Recapitulation.—For the management of manure from the homestead, the following rules of practice seem to result from the preceding discussion of theoretical principles, in connection with some recorded experiments.

1. To ferment dung-heaps from which mown or pulled weeds and woody fibrous refuse are excluded, until they have lost one-third of their weight; and even this in districts where manure is scarce, and where the motives for spending it in the most economical way are the strongest. To ferment it to this minimum degree previously to spending it on ARABLE land in autumn, or at a season when some time will elapse before the seed is put in. To ferment and purify it in a greater degree when intended for use just before a spring sowing. To ferment dung to be spent on GRASS-LAND until the strawy materials begin to dissolve.

2. To ferment dung-heaps in which weeds and fibrous vegetable remains or woody offal are laid to rot, until the roots and seeds of the weeds and the fragments of woody matter are decomposed. This kind of heap may properly be set apart for pasture as far as it will extend.

3. To save the drainings from dunghills as much as possible.

4. To disregard the loss of gaseous and volatile matters, both from the dunghill and from the surface of land; and to estimate it rather as a benefit, for the reasons given under "Fallowing." (pp. 28—31.) To make trial, nevertheless, how far a covering of earth upon a dunghill can be converted into a manure, where the matter of a dense and rapid exhalation may seem worth intercepting.

5. To avoid fermenting the dung-heaps described under 1. until the fibrous texture is totally destroyed, and the mass of manure becomes cold and soft,—where the manure is to be expended on a large tract, particularly on lands under the plough,—chiefly for these two reasons: first, to obviate the loss of fluid matter where a reservoir cannot be contrived: and secondly, on account of the exhaustion of the fermenting principle, which would be usefully set in action in foul soils; rather than for the other causes theoretically assigned in the *Elements of Agricultural Chemistry*: because, admitting a principle urged by Professor Davy, meriting a distinct notice, that the "ultimate results of excessive fermentation are like those of combustion," it is

* General Report on the Agricultural State of Scotland, in five vols. 4to.

reasonable to conclude, from the experiment related above, on the ashes of 15 cwt. of Barley Straw, that if the quantity of burnt straw had equalled the weight of strawy dung, the ashes would have surpassed the strawy manure in fertilizing effect. The ashes of various burnt vegetables are celebrated for their fertilizing power. To return to the object of checking fermentation beyond the proposed degree, spread the heap abroad. Heavy watering will at once abate the heat; but the heat will afterwards revive with increased fury, unless the stack be either trod down to exclude the air, or scattered and partially dried before it is again allowed to ferment.

6. In gardens, and on grounds cultivated on a small scale, and even on arable farms where rest by summer fallowing can be superseded by a constant full supply of manure, the utility of rotted dung is far above that of strawy unfermented litter or slightly fermented dung; because the latter is a nidus for insects; also because putrefying remains, if in contact with growing plants, must tend to injure the health of many species, and to deteriorate the flavour of the edible parts of plants, and especially of esculent roots.

ADDITIONAL NOTES.

Page 26. "By Fallowing."]—While this Treatise was in the press, an original critique on the 'Elements of Agricultural Chemistry,' appeared in the 'Farmer's Magazine.' The Conductor of it, who possesses great advantage for comparing the projects of theory with the results of practice, has expressed a deliberate dissent from Sir H. Davy's doctrine 'on Fallowing.' The grounds of opposition there taken coincide so closely in a few fundamental points—and so substantially in their tenor and conclusion—with the observations made on the same subject in the preceding pages, that it may be expedient to state that the passage in the Treatise (pp. 26—34) was printed off before the publication of the Magazine, and that the MS. of it had been in the hands of some friendly critics sufficiently long to establish for it an independent origin; having been dissected by a surgeon, weeded and pruned by a gardener, and examined for a degree by the principal of a college. This still leaves to the critique in the Magazine all the force of a corroborating authority; in which light I adduce an extract from it, with much satisfaction. The coincidence chiefly to be remarked, is in admitting many of the Lecturer's positions advanced as chemical facts, and in deriving from them counter arguments. But the points on which the Reviewer enlarges are not the same, and some forcible passages in his parallel course struck me as new, the natural effect of free deduction without communication.

"But with regard to his doctrine concerning fallowing, we differ from him entirely. He thinks a clean fallow 'may be sometimes necessary in lands 'overgrown with weeds, particularly if they are sands which cannot be pared 'and burnt with advantage; but that it is certainly unprofitable as a general 'system of husbandry.' Now, we think naked fallow to be chiefly useful on strong tenacious clay soils; and although it be true that the mineral earths in the composition of the soil, attract no new principles of fertility from the air, there are inferences deducible from his own doctrines which seem to recommend fallows for such soils. Waving the destruction of weeds, which can be more effectually accomplished by fallow, than by any drilled or green crop, we observe, 1st, That by exposing soil in large clods, to the action of the sun's rays, in spring and summer, it is heated to 120° of Fahrenheit, and often much more. By this its moisture is exhaled, and the clay comes somewhat to resemble that described by our author, which had been burnt with fire. It becomes more brittle, and less apt to cohere with subsequent moisture. Hence, the oftener our carse soils are treated with fallow, the more friable they become. 2d, When our author pronounced this severe censure upon fallows, he seems to have forgotten what he so often states in the course of his work, that after all the soluble matter in a soil is exhausted by cropping, there still remains much charcoal, the remains of woody fibre; that this charcoal imbibes a large proportion of oxygen when the air has access to it, but that it remains inert in the soil, unless a new fermentation be excited in it, by various means which he describes. Now, in clay soils this charcoal is effectually excluded from imbibing oxygen from the air, but is brought into a condition to do so by fallowing. The effect of this, and of its imbibing moisture, is its gradual conversion into carbonic acid, and carburetted hydrogen, for the nourishment of plants. Accordingly, experienced farmers have assured us, that

they have known land that had been long manured, and afterwards exhausted by cropping, have its fertility more restored by a fallow than if it had received a full dose of putrescent manure. Their experience may be accounted for by data furnished by our author; and we are sorry that, in this case, his conclusions seem to be in direct opposition to his premises. We so far, however, agree with him, that fallows are sometimes too often repeated, especially on sandy soils, where drilled crops may, in general, serve their purpose; but on cohesive soils we hold them to be occasionally indispensable."

Farmer's Magazine, No. LXIV. (dated 6 Nov. 1815.) p. 488.

P. 50. *It is decomposed*, &c.]—The sulphuric acid in gypsum will also combine with ammonia. Manufacturers of sal ammoniac have availed themselves of this, afterwards disengaging the ammonia with muriatic acid. This strengthens the motives for trying with gypsum composts containing animal filaments. Composts, rightly proportioned, are in general more efficacious than any simple manures.

P. 76. *The fifth argument is entirely practical, and the authority adduced in its support one of the highest.*]—The Author of the Lectures might have cited another great name, as an advocate for expending putrescible manure in a fresh state. From the 'Hints on Agricultural Subjects,' (by J. C. Curwen, M. P. of Workington Hall, Cumberland, Esq. 2d edit. London, 1809,) it may be collected, that the practice at the Schoose Farm was shaped upon this principle, but with many capital divergencies from the broad and indiscriminate track which owes its ease and simplicity to the nature of mere speculation.

"I should say, . . . bury the manure as deep as possible, and then sow the turnips directly on the manure, leaving twenty-four inches between the rows: this will afford ample room for the plough to work, which will not only admit complete cleaning, but in the operation furnish that degree of nourishment to the turnip, which in very dry seasons would be highly serviceable, and contribute greatly to the weight of the crop." *Hints*, p. 221.

"This method would also permit of fresh stable-litter being made use of, without the necessity of its undergoing that degree of fermentation which reduces it at least one-third in bulk; and, in my opinion, still more in efficacy. . . I have taken great care in having horse and cow dung mixed in equal quantities, and the muck-heaps formed into pyramidal shapes, so as to admit of their being easily covered with earth, which is collected for this purpose from head-lands and ditches. This method prevents the evaporation; and the gas imbibed with the earth makes it equally valuable with the dung. The making what is called manure pies is a common practice in Ireland. It serves greatly to increase the quantity, which must always be acceptable to the farmer." *Hints*, p. 222.

Mr. Curwen's method of applying manure in the field is but part of a system; therefore, before giving that method, it will be proper to state, that his first principle for bringing foul land into good tilth, and for superseding a naked fallow, by the relief of alternate green crops, is,—to leave such a space between the stitches of the green crops as will admit of working both with the plough and hoe throughout the season; a space double to what is commonly allowed. He holds, that by constantly turning the vacancies between the rows or beds, in every direction, he can in dry weather procure for the plants something like a compensation for rain, in the evaporation of moisture from the earth. "The first day's exhalation from ploughing is in the proportion of 950*lbs* of water per hour from an acre. The evaporation decreases on the second day a third part, and continues to diminish for three or four days according to the heat of the weather, when it entirely ceases; and is again renewed by fresh ploughing." *Hints*, pp. 211, 212.

"A field of cabbages were this year set on a very strong stiff clay, which previous to their being planted was in high tilth. The severe drought which succeeded the rains that fell soon after setting, baked the ground perfectly hard. The plants made little or no progress; they were seen by a friend of mine, on Monday the 26th of May, as I was commencing the breaking of the

ground with the ploughs. They were worked for the whole week. On the Saturday they were seen again by the same gentleman, and he could scarcely be persuaded they were the same plants The week had been very dry, with a hot sun, and strong north-east winds. The crop of last year was allowed to have been a very extraordinary one, and weighed thirty-five tons and a half per acre. Some of the cabbages were fifty-five pounds; they had only fourteen tons of manure upon the acre. My second principle is, to bury the dung as deep as possible, in order to retard the evaporation, and keep the heat in the ground, by preventing the atmosphere from acting upon it. It is a point to be particularly attended to, that the manure should be kept quite dry, which is done by having a deep trench in the centre of the space between the rows. By these two combined principles, I expect I shall succeed in obtaining equal crops, though but one half, and in some instances, only a third of my ground is occupied. To pronounce decidedly that this will be the case would require further experience than I can pretend to boast of. So many circumstances ought to be taken into consideration in every experiment, that many trials must be had before it can be pronounced altogether successful. I have the testimony of a very meritorious agriculturist, who has made several experiments upon this plan in garden husbandry, and who states the most favourable result. The gentleman I allude to is the Reverend E. Ellerton, of Colston, near Ulverstone. To such as have no option, like myself, but are obliged to set their potatoes on wet ground, the plan I have followed has in one particular been found to answer a most admirable purpose. It keeps the potatoes so perfectly dry, that in this unparalleled year of wet, where in most dry grounds the loss by decayed potatoes has been very great, I have had no loss whatever. I cannot boast of the weight of my crop, but indeed it was not to be expected, being set a month later than the usual time, and the vegetation destroyed by the frost in the very beginning of September, which is a month before what is common. I am by no means discouraged or dubious of the principle on which it was undertaken; and I hope to give it a very fair trial." *Hints*, pp. 213, 214.

"Dung, and all the animal mixtures, I bury as deep as possible, taking care that they shall lie deep. Lime, (the little I use being solely in compost,) schistus, . . . sand, &c. are used for top-dressings." *Hints*, p. 222. "I am strongly inclined to believe, that where the ground is laid dry, that manure can scarcely be deposited too deep; by so doing the evaporation is retarded, and consequently, the manure continues for a greater length of time to furnish nourishment to the crop." *Hints*, p. 268.

"The experiments I have made tend to establish the double advantage of well cleaning and working the ground. First, as it frees the land from weeds; and secondly, as it conduces to the growth of the crop. It affords likewise a very strong demonstration in favour of using the manure in its freshest state, by which not only the great usual expense of making dunghills will be saved, but the manure made to extend to the improvement of a third more land.

"Most of the farm I occupy was in that state of foulness as to require, according to general practice and opinion, a succession of fallows to clean it. Being unwilling to adopt a system which is attended with such loss, I determined to attempt to clean a part of it by green crops, and for such purpose to allow a much greater distance between the stitches than had ever been in practice. My first experiment on this plan was made on a crop of cabbages; they were planted in a quincunx form, allowing four feet and a half between each plant, in order to allow room for the plough to work in all directions. I adopted this plan of field husbandry, as affording the greatest facility in cleaning the crop, though I believe it was never before practised. Two thousand three hundred and fifty plants were set per acre (eight thousand is not unusual in the common method,) and each plant had, by computation, an allowance of a stone of manure, or less than fourteen tons per acre; though the common quantity is generally from thirty to forty tons per acre. The manure was deposited as deep as the plough could penetrate, drawn by four horses, and the plant set directly above it.

"The plough and harrow, constructed to work betwixt the rows, were constantly employed during the summer, and the ground was as completely freed

from weeds as it could have been by a naked fallow. The very surprising weight of my crop, which in October was thirty-five tons and a half per acre, and many of the cabbages fifty-five pounds each, were matter of surprise to all who saw them, as well as to me; and I could assign no satisfactory reason for the fact. The quality of the land was very indifferent, being a poor cold clay, —the manure was very deficient of the usual quantity,—the plants when set by no means good,—in short, there was nothing to justify the expectation of even a tolerable crop. I did not find any thing in the accounts from cultivators of cabbages to afford me a solution of my difficulties, or any clue to explain it. By mere accident I met with the Bishop of Landaff's experiment, ascertaining the great evaporation from the earth, as related in his admirable Treatise on Chymistry; singular as it may appear, this very interesting experiment had remained for thirty years without any practical inferences being drawn from it applicable to agriculture. It appeared to me highly probable, that the rapid advance in growth made after the hoeing of drilled grain, was attributable to the absorption of the evaporation produced from the earth, and was the cause of the growth of my cabbages. With great impatience and anxiety, as I had the honour to inform you last year, I looked forward to the ensuing season to afford me an opportunity of continuing my experiment. I had long been a strenuous advocate for deep burying of manure, though my sentiments rested chiefly on opinion; this appeared to open a field for incontestable proofs of its advantage. My cabbages were last year planted on the same plan as the former year. Fortunately I extended the same principle to my potatoes, which I was obliged to set on wet strong ground, from want of a choice of land. My annual quantity of potato ground is from sixty to seventy acres. They were set in beds three feet long, and two feet broad, leaving four feet and a half between each bed lengthways, and three feet endways. On each acre there were 1230 beds, and 6150 sets, or five to each bed, viz. one at each corner, and one in the middle. The sets of potatoes, when planted according to the usual most approved practice, in three feet stitches, and nine inches apart, amount to about twenty thousand. In the present, and indeed in all seasons when potatoes are scarce, the saving in planting is a considerable object. A great advantage also arises in being able to keep the potatoes and manure from wet. In the late uncommonly wet season I sustained little or no loss in my mode, which was not the case in many of the driest grounds. This plan unites hand hoeing with horse culture, and will be found serviceable in wet soils.

"The lateness of planting, together with the premature frosts, prevented my forming a fair judgment as to the quantity per acre which might be obtained by this method. My view in fixing upon this plan was, to enable me to judge of the effects of evaporation, by being able to continue my operations for a longer period. I have no doubt but that in common seasons, notwithstanding the increased distance, the whole ground would be covered.

"My experiments on cabbages this season, commenced by planting them early in April. From the rain which fell subsequently, and continued till the beginning of May, succeeded by severe east winds, the earth became so hard and baked, that the plants had made very little progress.

"In the first week in June the ploughs were set to work: as they started, Mr. Ponsonby, of Hail Hall, was present, and saw the crop; it was with difficulty that the ground was first broken, but by the end of the week it was brought into fine tilth. Notwithstanding the whole week had been dry, with a strong sun and severe east wind, yet such was the progress in growth of the cabbage, that when seen again by that gentleman on the Saturday, he could scarce be persuaded they were the same plants.

"During these operations I had been making constant experiments with glasses, contrived for the purpose, to ascertain the quantity of evaporation from the land, which I found to amount, on the fresh ploughed ground, to nine hundred and fifty pounds per hour on the surface of a statute acre, whilst on the ground unbroken, though the glass stood repeatedly for two hours at a time, there was not the least cloud upon it which proved that no moisture then arose from the earth.

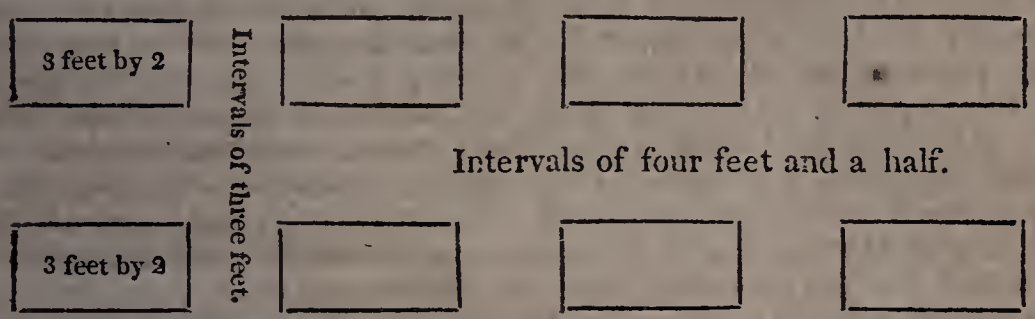
"The evaporation from the ploughed land was found to decrease rapidly after the first and second day, and ceased after five or six days, depending on

the wind and sun. These experiments were carried on for many months. After July the evaporation decreased, which proves that though the heat of the atmosphere be equal, the air is not so dense. The evaporation, after the most abundant rains, was not advanced beyond what the earth afforded on being fresh turned up. The rapid growth of my potatoes corresponded perfectly with the previous experiments; and their growth in dry weather visibly exceeded that of other crops where the earth was not stirred." *Hints*, pp. 269..274.

"The evaporation from dung is five times as much as from earth, and is equal on the surface of an acre to 5000 pounds per hour. By making use of dung in its freshest state, the farmer may extend his cropping to one-third more land with the same quantity of manure. It is with regret that I have viewed in many parts of the kingdom the quantity of manure which is exposed on the surface, and tends to no good. I am strongly of opinion, that in all light soils, if the manure was buried in trenches as I propose, and the turnips sowed above it, that more abundant crops would be procured. By cleaning with the plough, great advantage would be derived to the crop, from the evaporation yielded by the earth. Hot manure might also be used. By fermentation dung is reduced to one half its bulk, and its quality reduced in a much greater proportion. The manure now commonly taken for one acre of broadcast, would if deposited whilst hot in drills, answer for four acres, and the crop produced be much more." *Hints*, p. 275.

These extracts embrace three important things: 1. GREEN CROPS WITH WIDE INTERVALS. 2. THE APPLICATION OF PUTRESCIBLE MANURE IN A FRESH STATE. 3. THE PROPOSED EXTENSION OF THIS PRACTICE TO LIGHT SOILS.

In relation to the first head, the copious evaporation of moisture from newly turned earth is an important discovery. The wide intervals in the green crops are to provide for its free application. The intention is judicious: but in leaving intervals wide enough for a plough to work, the sacrifice of area may outweigh the benefit, especially if the plants are not capable of reaching a size in proportion to the space between them. The large field cabbages are perhaps most likely to afford a compensation in weight. In what degree the usual field crops would be thus diminished is highly requisite to be computed; for if the produce from an acre is diminished every alternate year in a material proportion, the sacrifice in seven or eight years may be equal to one naked fallow in the same time, or may exceed it. When potatoes are planted in the manner above described,



The unplanted ground is as 11 to 2; and can it be expected that the roots will send out runners halfway across the wide intervals? or that the weight of crop can sustain a competition with one raised from closer beds? We may conclude that further experiments produced the conviction that such green fallows are on the average unprofitable; for at the date of the letter cited in the preceding treatise, (p. 31. n.) The President of the Workington Agricultural Society had become reconciled to a summer fallow in rotation with white crops, on a clay soil. But the history of experimental farming is a history of revolutions in which practices which seem to be the very same are alternately abandoned and resumed—seem to be, but they are not, the very same; for the circumstances of positive knowledge are different by the advancement of a stage, and the preponderating obstacle which last turned the scale, is removed by a new contrivance. Thus, a clay soil can be rendered fit for green crops by a top dressing of clay ashes; (*Treatise*, p. 54) and whether the system of

summer fallowing is entirely superseded by this resource, will depend now upon a fair comparison of the expense and benefits found to attend both courses. The letter of Mr. Curwen to Mr. Dempster, (adverted to in the preceding treatise, p. 55. n.) has these two passages. "I conceive that I am justified in anticipating a rapid increase of green crops, the means of producing them being now within the reach of every one."—"I do not think I am too sanguine in viewing the general adoption of the system of surface soil and clay-burning, as likely to be the most important discovery for the interests of agriculture, that has occurred since the introduction of the turnip into Norfolk by Lord Townsend."

The second subject which we are stimulated to consider anew by Mr. Curwen's *Hints*, is, The application of putrescible manure in a fresh state. It is plain that all the instances, above collected, of this application relate only to arable land.

Now, if we advert to the local climate, and the soil, at the Schoose Farm, we may see causes why such a practice, as part of a system, may confer partial benefits; and why its positive defects may be compensated, its disadvantages counteracted. 1. The climate is moist: "42 inches of rain fall in the twelve months, whilst in Norfolk they have but 22." (*Hints*, p. 211.) 2. The soil is "a stiff loam, partaking in a great measure of clay" (p. 262.) 3. Deep ploughing for the winter fallow is practiced there; the furrow at the first ploughing for a green crop is described as from 11 to 14 inches deep. (p. 211.) The Author of the *Hints* notices, however, the objections which the advocates of other systems have made to this part of his: "More diversity of opinion is found to exist as to deep and shallow ploughing than might be expected. I should deem shallow ploughing four inches; medium, six; deep, nine: but every six years I should advise making the winter fallow twelve; I have found it invariably to answer, and it is with satisfaction I see it becoming very general in the county of Cumberland." (p. 237.)

To connect these circumstances.—If strawy litter is buried in a deep furrow under a drilled ridge, the channel thus created will at least operate as a drain; which must be a benefit on a clay soil in a moist climate. Supposing the fresh litter, dung, or animal refuse lying deep from the surface, not to be decomposed till the following season, yet if there be already in the soil sufficient aliment of any kind for the plants the first year, the farmer will not be disappointed at harvest time: meanwhile there is a provision of manure for the following year; and the same course may be annually repeated with a diminished hazard of starving the crop. Supposing, on the contrary, the fresh manure to decompose in that situation, the first season, the deep burying of it leaves a layer of earth for the growing roots: thus the baneful contact of hot dung, putrefying vegetables, and rank animal fluids, will be eluded. Still let all the accidents be fortunate, some losses and waste must attend this way of depositing manure, either from fibrous matter getting too deep to be acted upon by the atmosphere, or by rich fluids irrecoverably sinking into the subsoil beyond the attraction of annual crops.

As to grass-lands, the practice at the Schoose Farm appears to be, to manure these with unputrescible substances, in a shape for sinking presently into the surface; such as coal-ashes—street-rakings—sea-sand—and schistus (coal-slate) previously pulverized by mixture with caustic lime, six parts to one of lime. In this, there is nothing to countenance the project of spreading fresh litter on pasture. It may be observed, that although all these articles must improve a soil of clay, yet only the street rakings can have much power as containing manure for a plant to consume. If clover and rye-grass, under treatment which decidedly improves the texture of the soil, now and then turn out a bad crop, it may be attributed to a deficiency of aliment; plants cannot get plump on a good lodging, if poorly fed. The least rapacious feeders have some appetite.

Thirdly, our extracts from the *Hints* contain this important suggestion: "I am strongly of opinion, that in all LIGHT SOILS, if the manure was buried in trenches as I propose, and the turnips sowed above it, that more abundant crops would be produced." The agriculturist who combines knowledge with invention, enterprize with experience, liberal communication with vigilant in-

quiry, and candidly declares the results of his own experiments, will necessarily frame a system of farming both beneficial to his own estate, and that may be transferred with benefit to lands similar to those which he has long managed. If he propose to transfer the system to an opposite sort of soil, a mere opinion from such an authority, strongly expressed, may mislead. Practical men who have tried the application of long littery dung, and seen it extensively tried, on LIGHT SOILS, pronounce decidedly that it is inferior in efficacy to well fermented manure. With regard to the soil itself, the want of due tenacity, one of the inconveniences of light sandy land, is increased by loose litter, so that the seeds are more exposed to be blown out, or the plants unrooted. As to the crop, it consults the habit of hardly any plant but the potato; and even for this the long litter should be either slightly fermented, or but just covered with earth, that air, heat, and moisture, may help it to decompose.

P. 83. *To disregard the loss of gaseous and volatile matters, both from the dunghill, and from the surface of the land; and to estimate it rather as a benefit.*]—One of the principal gaseous matters escaping from dunghills and fallows, is ammonia or volatile alkali. The Author of the elements dwells much on the magnitude of this loss. But what is Ammonia? And is it to be valued for its contributions to the roots of the living plants? or for its chemical agency on vegetable, animal, and mineral substances, lodged in the manure or in the soil? Ammonia is composed of nitrogen (or azote) and hydrogen, both gases; the first an abounding element of common air; the second the basis of water, and though not properly a constituent of the atmosphere, frequently suspended in it; say eight parts of azote to two of hydrogen; for the proportions given by chemists vary. Sir H. Davy has also separated from ammonia a substance that will unite with mercury without destroying its metallic lustre. It may help us to form a clearer notion of ammonia for practical purposes, merely to trace some of the methods of procuring it artificially. The Egyptians obtained what Pliny calls sal ammoniac by sublimation from the urine of camels; and in modern times, the sal ammoniac of commerce, by sublimation from fuel formed of the dried dung of cattle which had been fed on a spring grass, described as somewhat like clover. The European chemists have successively extracted it, by varied processes, from bones divested of fat—from urine—from promiscuous animal solids—from hair, fur, feathers—peltry dressed with the hair—burnt in furnaces, and sublimed; also from soot. This pungent aroma is always generated by the combustion of animal filament, especially those hollow tubes and fibres which owe their consistency to a portion of lime. It occurs constantly and abundantly in animal matter; while pure vegetable substances (those which have not been mixed with animal matter) do not invariably contain it, and such as give it out on distillation afford minute or evanescent quantities. The fruit of the Green Gooseberry (*Ribes Grossularia*) yields it on analysis; also the pollen of tulips, 1 part in 20. From the highly volatile nature of ammonia, the plants in which it is found may easily derive it from the atmosphere; nor can its presence in the soil be considered necessary to the growth of any plant, as aliment.

Is volatile alkali to be valued for its chemical agency in a dunghill, or other heap of putrescible manure? As many animal and vegetable substances, and some fossil salts, can be decomposed by this alkali, its presence in dung-heaps, in fallows, and in all grounds preparing for crops, must be esteemed highly useful. But then its utility would be obstructed, not promoted, by arresting its free action. To attempt to detain it by *avoiding fermentation* is to prevent its developement, if not its formation. Ammonia in action will decompose the crystals of salts of iron. Thus, if peat containing that pernicious compound be laid upon a putrefying dunghill, the peat, as soon as it has been thoroughly steamed with animal alkali as well as fermented, will be rectified no less than if it had been mixed with lime. So decayed tree-leaves, or wood containing tannin, will be sooner fitted for manure than if fermented alone. In all this we find additional motives to cover a fermenting dunghill with a case of earth, or compost containing dry vegetable matter, that the fugitive vapours may be intercepted before their virtue is exhausted.

To detain ammonia in the bosom of land, except in the shape of a salt, may

require a talisman, like that which confined the genie in a copper vessel. From the number of animal substances, including dungs, which evolve it, when either burnt, or highly fermented, or mixed with caustic lime, it may be expected to be redundant rather than deficient in most cultivated soils; and the experiments noticed in p. 57, shew that a small quantity of any salt of ammonia must be diluted to great weakness, by mixture with water, not to be in excess. I believe those soils in which sal ammoniac is found native, are not very fertile; but nothing positive can be stated on this head, until the travellers in countries which afford it, give us more particular information. Muriate of ammonia has been found native in some of the mountains of Bucharia, and Thibet; and in the waters of some lakes in Tuscany. It occurs also in small quantities near the neighbourhood of some volcanoes. The sal ammoniac of Pliny has been found in a fossil state, below the sand, in a district of Cyrenaica, the modern Desert of Barca.

The agency of free unconfined ammonia must be of unqualified benefit to fallow land, as far as dormant vegetable matter, or other substances of which the decomposition is desirable, lie in the way to intercept this stimulating vapour; nor is it easy to imagine a case of exception previously to putting in the plants. Although in a glebe which is freely turned and exposed to the atmosphere, the volatile alkali, latent in animal manures before fermentation, has a tendency to dissipate into thin air, why should we seek to obstruct its spontaneous flight, at the expense of losing many certain advantages, by leaving the surface bound and indurated for want of tillage? Could we seal up the pores of the earth, two powerful considerations might reconcile us to the liberation of this alkali from the bosom of a fallow, before the plants are put in. On the one hand, as far as any substance is active in decomposing vegetable matter, its presence in a copious degree cannot be accounted serviceable to the roots of growing plants. It is true that most annual plants are less susceptible of injury from the contact of putrifying vegetable matter than shrubs and trees; perhaps because in a small plant, of which every part is growing, the principle of life is stronger; whereas the hard roots of a tree contain wood that has done growing, and is therefore unable to resist the contagion of a rotting substance. Still even summer annuals or tender exotics are injured by the steams of recent dung; and in the preparation of stable dung for hot-beds, it is found indispensable to let the first fermentation expend its strength, until it has come to what gardeners call a *sweet heat:* meanwhile, liberated ammoniac goes off in clouds of vapour, betraying itself by an offensive smell: in this the object commonly proposed is merely to expend a furious heat; but the loss of ammonia is an inseparable effect, and no doubt of equal benefit. The time which elapses before common weeds will grow on a dunghill is another indication not to be disregarded: it seems alone a confutation of the doctrine that fresh putrescible manure is at once food for plants. On the other hand, it is reasonable to conclude, that, whatever plants are constituted for receiving into their growing substance, a portion of ammonia can separate from air and from water sufficient supplies of its two elements, and appropriate them by the admirable provisions of Nature's chemistry.

In regard to the soil, it does not seem to be making the most of manures containing ammonia, to lay them on the surface of fallow land. If they are turned in at a slight depth, so as not to obstruct the required fermentation, the ammonia will steam many fragments of vegetable, animal, and fossil remains, before it escapes through the covering of earth. But all such manures are capable of more complete management in a compost dunghill.

THE END.